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COMPOSITE DATABASE INTERFACE USERS MANUAL

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This report provides a description of the Composites Database Interface (CDI) program and includes an explanation of the purpose of CDI, a description of the language and the system, and a demonstration of the use of the system with a complete example.

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TABLE OF CONTENTS

SUMMARY

The information presented in this document provides a description of the Composites Database Interface (CDI) program and its use and functionality. A brief description of each section of the manual follows.

- Section 1 explains the purpose of the Composites Database and the Interface programs.
- Section 2 describes the language in which the system programs are written.
- Section 3 provides a system description, including an enumeration of the required hardware and software.
- Section 4 describes the computer start-up procedure which enables the user to operate the CDI system.
- Section 5 provides an overall description of the CDI system and how it is run.
- Section 6 demonstrates the use of the CDI system with a complete example.
- Section 7 lists and describes the schema of the Composites Database.

The Appendices contain useful reference information for the CDI program, including sample reports, and copies of all data entry forms, help screens, and input/output files associated with the database and program. Complete program listings and a listing of the database schema are also provided.

1 PURPOSE

The Composites Database and Composites Database Interface (CDI) were designed to provide a computerized means for storing and maintaining properties of composite materials and for making the data available for use in analysis and design. Applications pertinent to this task include data entry and modification functions, report generation capabilities, and the ability to create material data files for use with three finite element analysis programs, ANSYS, and NIKE2D and DYNA2D, both through the MAZE preprocessor. Currently, the database contains identification and material property data on both unidirectional and laminated composites.

In an additional application, laminated plate theory is used to create quasi-isotropic and general layups from unidirectional composites; the resulting data is stored in the database. This document provides thorough and accurate descriptions of the various components of the Composites Database and Composites Database Interface.

2 LANGUAGES

The Composites Database was developed using the R:BASE For DOS database management system [1]. The CDI system programming was done using the R:BASE For DOS application programming language. The R:BASE application language was chosen for program development because of its ability to communicate directly with an R:BASE database. The language has features such as direct database queries, data manipulation, and report generation, making it ideal for this programming task.

3 SYSTEM DESCRIPTION

The Composites Database and the Interface programs are designed to run on an IBM personal computer or compatible. R:BASE For DOS, which is necessary to access the database and run the programs, requires the use of a hard drive with about 4 Megabytes of disk space available. Expanded main memory of 640 Kilobytes is also required.

The entire CDI system is contained inside of a system shell in a modular format. Within this shell are numerous application programs and a database. The database schema and data are stored in three binary files that are only accessible using R:BASE. These files are named COMP1.RBF, COMP2.RBF, and COMP3.RBF, and store the database schema, its data content, and its indices, respectively. A complete listing of the database schema may be found in Appendix 6.

The application programs are also stored within a set of files. Each file corresponds to one or more applications or functions within the shell. The files required to run the CDI are MENUS.PRO, COMP.CMD, HELP.CMD, DATA.CMD, VIEW_RPT.CMD, LAM.CMD, FILES.CMD, ANSFILE.CMD, ANSUNI.CMD, ANSLAM.CMD, LAMNAME.CMD, UNINAME.CMD, T2.CMD, T4.CMD, D_BLOCK.CMD, ANSFGEN.CMD, FIX.CMD, MAZFILE.CMD, MAZUNI.CMD, MAZLAM.CMD, and MAZFGEN.CMD. Complete application file listings are included in Appendix 5. Note that MENUS.PRO is a binary file; therefore, the ASCII equivalent, MENUS.APP, is included in Appendix 5.

4 START-UP PROCEDURE

To clarify the textand illustrations in this manual, sans serif font (sans serif) is used to designate any text that is viewed on the computer screen. Text entered by the user is indicated by a bold typewriter font (**`typewriter`**). In addition, italics (*italics*) is used to represent any CDI menu name or menu item.

To boot the personal computer from its hard drive, leave the floppy drive open and empty when turning on the computer. Respond appropriately to prompts for the current date and time. A C> prompt will automatically appear, indicating that the C drive is active. At the C> prompt, type the following three commands.

```
C>CD\COMP
C>PATH C:\RBASE
C>RBASE
```

The first command changes the subdirectory to that containing the Composites Database and program files. The next command sets up a path to the drive and directory containing the R:BASE For DOS files, providing the user access to and use of all of the files in the R:BASE directory. At this point, by typing the final command, the R:BASE For DOS database management system is started.

Once inside of R:BASE, the **Prompt by Example** main menu will appear. The user may enter R:BASE commands directly or may immediately run the CDI program.

5 RUNNING THE PROGRAM

To run the Composites Database Interface, first press [Esc] at the **Prompt by Example** main menu to enter the R:BASE command mode. The command mode is signified by an R> prompt on the screen. Next, type the following command at the R> prompt:

```
R>RUN COMP.CMD
```

This command runs the program COMP.CMD, which will in turn initiate the other programs which make up the Composites Database Interface. Complete program listings are included in Appendix 5.

An introductory screen will appear, prompting the user to press any key to continue. Upon pressing a key, the user will then see the CDI main menu, illustrated below.

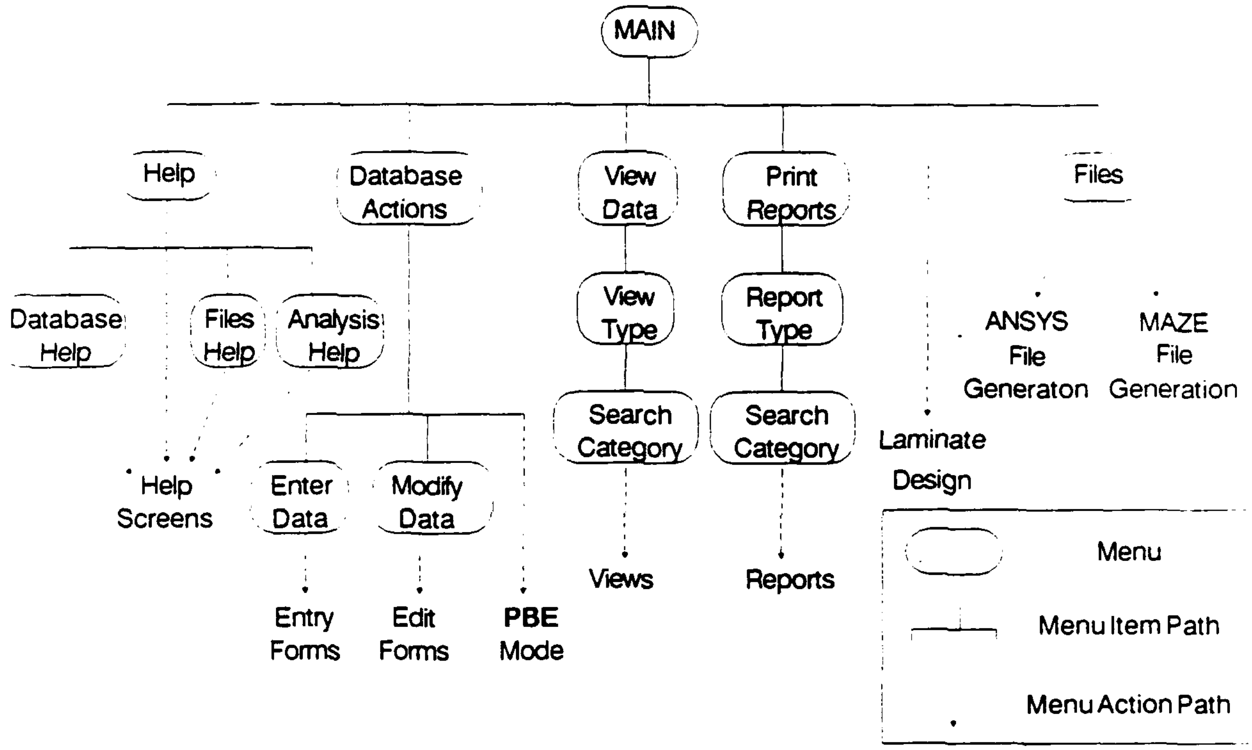
```
================== *** CDI MAIN MENU (Make a selection) *** ==================
  HELP    DATABASE    VIEWS    REPORTS    LAMINATE    FILES    ANALYSIS
  EXIT
```

From this menu, the user may access any available program option. To select a menu option, first highlight that option by either typing the first letter (or number for a vertical menu) of the desired action or by using the arrow keys to move to the desired option. Press [Enter] to choose that menu item. Briefly, the top-level menu options function as described below:

- *Help*: Generates a submenu listing the various categories for which the user can view help screens.
- *Database*: Lists available database options, allowing the user to either enter or modify database data, or execute R:BASE commands directly using the **Prompt by Example** mode.
- *Views*: Creates submenus of available data categories and search items for which screen views of the data can be generated.
- *Reports*: Creates submenus of available data categories and search items for which hard-copy reports can be generated.
- *Laminate*: Allows the user to generate quasi-isotropic and general layups using existing unidirectional composite data and store the resulting property data in the database.

- *Files*: Generates interface files of selected material property data suitable for use with either the ANSYS finite element analysis program or with the MAZE preprocessor for the NIKE2D and DYNA2D analysis codes.
- *Analysis*: Currently initiates no action. Indicates a future capability to perform finite element analysis by providing direct access to the MAZE and ANSYS programs.

Each option is described in more detail in the following subsections. Refer to Section 6 to see a detailed example of each action being used. The following figure presents a flow of program control diagram, which illustrates the relationships among the available menu items discussed below.



5.1 Help

Selecting the *Help* option from the CDI main menu calls the HELP.CMD program, which generates, on screen, the *Help* menu shown below.

```
*** HELP MENU  (Select a topic for help menus or screens) ***
DATABASE   VIEWS   REPORTS   LAMINATE   FILES   ANALYSIS   EXIT
```

Note that the *Help* menu is very similar to the CDI main menu screen except for the title. This is because the *Help* option allows the user to view context sensitive help screens that describe any top-level menu option. Selection of some of the options on the *Help* menu may lead to further menus, which provide the user with additional, more detailed help information.

Help screens contain descriptive information similar to that presented in the following subsections. Each provides general instructions about how to perform the function in question, and might discuss several possible options or command variations. A complete listing of all help screens is included in Appendix 3 for reference purposes.

If the help screen is longer than twenty lines, scrolling will pause after the screen is full until the user has pressed a key. At that point, the next page of information will scroll to the top of the screen. When the entire help message has been read, the user may press any key to return to the *Help* menu displayed previously. Press [`Esc`] between pages of help to exit immediately to the previous menu.

5.2 Database

Selecting the *Database* option from the CDI main menu initiates the DATA.CMD program and causes the following menu to appear.

```
*** DATABASE ACTIONS (Select an action) ***
        (1) Enter database data
        (2) Modify database data
        (3) Enter R:BASE directly
        (4) Exit to previous menu
```

From the *Database Actions* menu, the user can elect to either enter new data into the database, modify existing database data, or enter R:BASE directly to perform various tasks. Both the data entry and data modification options allow the user to manipulate data using on-screen forms. Selecting the *Enter R:BASE Directly* option places the user in the R:BASE **Prompt by Example** mode, from which any R:BASE command can be executed directly. To select any of these options, type the associated menu item number and press [`Enter`].

5.2.1 Entering Data

The *Enter Database Data* option of the *Database Actions* menu allows the user to enter new data into the database using on-screen forms. When this option is selected, the following menu appears, illustrating the available categories of data to be entered.

```
*** ENTER DATABASE DATA (Select a data category) ***
        (1) Unidirectional composites
        (2) Laminated composites
        (3) Exit to previous menu
```

The user must select from this menu the type of composites data which he wishes to enter, either unidirectional or laminated composites. Unidirectional composites data is placed into the database tables UNICOMP and UNIPROP; laminate composites data is placed into LAMINATE and LAMPROP. Refer to Section 7, entitled **Database Schema**, for information about the specific contents of these tables.

The user is then prompted to enter a composite name; the laminate code is also required for a layup. If the composite does not duplicate an existing one, the user is prompted for an identification code to be used in the database, which is also checked for duplicity. If a row already exists in the database that matches the data which the user is trying to enter, he is given the opportunity to edit that row or to enter a different one.

After the user provides a correct response to each prompt, one or more data entry forms, corresponding to the appropriate database tables, will appear consecutively on the screen. Each contains numerous prompts. The data entered on each form corresponds to a single row in a table; each prompt corresponds to a particular field of that row. A sample data entry form is illustrated below; each form in the CDI system is included in Appendix 1 for reference.

LAMINATED COMPOSITE MATERIALS

IDENTIFICATION CODE: COMPOSITE NAME:
LAMINATE CODE:

COEFFICIENTS OF NORMALIZED LAMINATE STIFFNESS MATRIX

A11:	(psi)	A12:	(psi)	A16:	(psi)
A22:	(psi)	A26:	(psi)	A66:	(psi)

ELASTIC MODULI:
E1: (psi)
E2: (psi)

THERMAL EXPANSION COEF.:
ALP1: (in/in-° C)
ALP2: (in/in-° C)

POISSON'S RATIO:
NU21:

SHEAR MODULUS OF ELASTICITY:
G12: (psi)

A highlight cursor will appear beside the first prompt. Data is entered into the fields by typing a response to each prompt, followed by a carriage return. To enter a null value into a database field, leave the corresponding field of the data entry form empty. Move from field to field using either the [Tab] keys or the arrow keys. On some forms, the highlight cursor will not move into certain fields already containing data. The data values in these fields are included only for reference purposes; they cannot be changed using that particular form.

Once the data in a form is complete and accurate, press [Esc] and a small menu will appear across the op of the screen. This menu, illustrated below, offers several options for handling the newly entered data.

Add   Edit Again   Discard   Quit

Choose *Add* or *Quit* to enter the row into the database, *Edit Again* to return to the data entry form on the screen for that same row, and *Discard* to clear the form without saving the row. A single row is added to the database with each form; control is then either transferred to another applicable form or back to the *Enter Database Data* menu. The user may repeat the selection and entry/edit process for additional rows.

5.2.2 Modifying Data

The *Modify Database Data* option of the *Database Actions* menu allows the user to edit or delete existing data from the database using on-screen forms. Upon selection of this option from the *Database Actions* menu, the following menu appears.

*** MODIFY DATABASE DATA (Select a data category) ***

(1) Unidirectional composites
(2) Laminated composites
(3) Exit to previous menu

Note that the *Modify Database Data* menu is very similar to the *Enter Database Data* menu, allowing the user to edit data about either unidirectional or laminated composites. Again, he must first identify the desired row by typing the composite name. If a corresponding row does not exist in the database, the user is prompted to either enter that row as a new one in the database or edit another. Thus, the *Modify Database Data* option enables the user to add data if necessary.

If the user chooses to edit data that does exist in the database, the edit forms corresponding to the selected data category appear consecutively on the screen. Each form has numerous prompts, similar to the data entry form, except that the prompts are followed by fields containing data values for the first applicable row in that table, i.e., the data values are automatically displayed.

A small menu, similar to that illustrated below, will appear across the top of the form.

Edit	Save	Delete	Reset	Previous	Next	Quit

Select *Edit* to access the first field in the form. To change field values, simply type over the current data value and press return. Move between the fields using either the [Tab] keys or arrow keys as described earlier. The highlight cursor will not move into certain fields on some forms. These fields are included only as reference fields and their values, therefore, cannot be changed.

Press [ESC] to return to the menu which appeared previously at the top of the form. The remaining options on this menu function as follows: *Save* enters the changes to a row into the database, *Delete* removes the row from the database entirely, and *Reset* restores the form fields to their original values, losing all changes made during the current editing session. *Previous* and *Next* allow the user to page between those rows in the table which meet the specified conditions, while *Quit* exits the form, saving the data in the current row unless otherwise directed by the user.

5.2.3 Entering R:BASE Directly

The *Enter R:BASE Directly* option of the *Database Actions* menu allows the user to enter the R:BASE **Prompt by Example** (**PBE**) mode, from which various R:BASE commands can be executed. Upon selecting this option from the *Database Actions* menu, the following message appears on the screen.

> PRESS ANY KEY TO ENTER THE R:BASE PROMPT BY EXAMPLE (PBE)
> MODE. TO RETURN FROM PBE TO THE DATABASE ACTIONS MENU,
> PRESS [ESC] AT THE PBE MAIN MENU SCREEN.

As instructed, press any key to enter the R:BASE **PBE** mode; the **PBE** main menu will appear. Numerous selections can be made from this menu, allowing the user to initiate one of the many R:BASE database operations available in this mode.

Possible **PBE** actions of interest to us include modifying data, querying the database, using SQL commands, and accessing operating system utilities. Most commonly needed operations can easily be performed using the appropriate **PBE** options. Certain actions, however, such as modifying the database structure, or partially changing the identification code for a particular composite, should be avoided, as it will lead to inconsistencies within the database or between the database and the CDI programs.

In executing a **PBE** command, the user must first select, from the main menu, the type of action to be performed. Screen prompts then help direct the user to generate a proper R:BASE command. Finally, the user must choose to either reset, edit, or execute the command, get context specific help, or quit to the previous menu. As indicated in the introduction to **PBE**, press [Esc] at the **PBE** main menu to return to the *Database Actions* menu.

5.3 Views

The *Views* option of the CDI main menu allows the user to view selected data from the database on the computer screen. The user must specify the type and amount of data to be viewed; this is done through the use of several submenus. When the *Views* option is selected, the VIEW_RPT.CMD program is run, and the *View Data* menu, shown below, appears on the screen.

```
*** VIEW DATA ON SCREEN  (Select a data category) ***
        (1) Unidirectional composites
        (2) Laminated composites
        (3) Exit to previous menu
```

As when entering or modifying data, the user must first determine whether he wishes to view data on either unidirectional or laminated composites. He then must select from a third menu, the *Type of View* menu, indicating whether he wishes to see identification or material property data. Each of the successive *Views* menus are similar to the one illustrated above and are not shown here because of space considerations.

An identification view provides general data about a composite. For a unidirectional composite, an identification view lists the following data: identification number, name, fiber, and matrix. For a laminated composite, the same view lists identification number, composite name, and laminate code.

Material property views, on the other hand, are more detailed. In addition to the above information, a material property view might also indicate how the composite was processed, in what form it is available, and various material properties, such as elastic and Young's moduli, thermal expansion coefficients, Poisson's ratio, and density.

The final item which the user must supply in order to produce the view is the search category. For unidirectional composites, the user may report on the data for a particular class of composites, or for all available materials. Laminate data may be either selected by composite name or for all available composites. As an example, a portion of the unidirectional property view is shown below.

```
A SUMMARY OF PROPERTIES OF
UNIDIRECTIONAL COMPOSITE MATERIALS

ID CODE        NAME        CLASS     FIBER     MATRIX
-------        ----        -----     -----     ------
U1             T300/5208   CFRP      T300      N5208

PRODUCT FORM:  Tape or cloth          PROCESSING:  Autoclave
EX:  2.63E7  (psi)       ALPX:  2.E-8   (in/in- C)    NUYX:  0.28
EY:  1490000. (psi)      ALPY:  2.25E-5 (in/in- C)    NUXY:  0.015863
GXY:  1040000. (psi)                 DENSITY:  3.08E-5 (lbf-s^2/in^4)
```

5.4 Reports

The *Reports* option of the CDI main menu is identical to the *Views* option, except that hard-copy reports, rather than on-screen views, are generated. The information presented in the previous subsection, therefore, is applicable to both views and reports. The main *Reports* menu is entitled **Print Database Reports** rather than *View Data on Screen*; otherwise it is the same as shown in the previous menu illustration.

Before attempting to print a report, ensure that the printer is on-line and is correctly loaded with paper. Samples of each report are included in Appendix 2 for reference.

5.5 Laminate

The *Laminate* option of the CDI main menu allows the user to design both quasi-isotropic and general laminates from unidirectional composites data which has been stored previously in the database. The newly generated laminate data, which includes stiffness coefficients and material properties, is then stored in the database.

Layups are designed using laminated plate theory, which is the current industry standard, as documented in reference [3]. For the reader's convenience, all pertinent equations have been summarized in Appendix 7 of this manual.

As input to the *Laminate* option, the user must provide the name of the unidirectional composite and, for a general laminate, the laminate code for the layup to be designed. The laminate data is generated based upon the material properties of the unidirectional composite. If a necessary property is not found in the database, the user is prompted to either enter an approximate value or abort processing. This value is only used for computing laminate property data; it is not stored as a property of the unidirectional composite. To enter a value into the database, use the *Modify Database Data* option of the CDI main menu.

The laminate code, from which the layup is designed, should be carefully entered in the following format:

```
[orient(vol)/orient(vol)...]factor
```

where *orient* and *vol* are the orientation and volume fraction of each layer in the laminate. Orientations are entered in degrees where counter-clockwise angles are positive, while volume fraction is a dimensionless quantity.

Factor is an optional parameter which indicates that the laminate code between the brackets represents only a portion of the layup, or a sublaminate. An *S* indicates that the sublaminate is repeated symmetrically; a digit represents the number of repeating sublaminates in a group.

For example, the code [0(3)/90]2 identifies the same laminate as the code [0(3)/90/0(3)/90], indicating that three plies in the zero direction are followed by one in the ninety direction, and that this sequence is repeated twice in creating the layup.

By definition, a quasi-isotropic laminate is one in which the elastic coefficients at zero and ninety degrees of rotation are equal [3]. They approach isotropy, in other words. To design such a laminate, orientations of zero, ninety, plus forty-five, and negative forty-five degrees are laid up in equal volume fractions. The order in which the plies occur is not significant; the laminate code could therefore be [0/90/45/-45], [45/90/-45/0], or many other variations. In the Composites Database, a quasi-isotropic laminate is identified by the laminate code "quasi-isotropic."

The program LAM.CMD contains the actual code for this main menu option, and allows the user to design the single quasi-isotropic laminate for each composite, and as many general layups as desired. Subroutines T2.CMD and T4.CMD are called to transform the coordinate systems of various properties during ply rotation.

Additional prompts in the program require the user to provide unique identification codes for each new laminate that is designed and entered into the database.

For each new laminate, six stiffness coefficients are placed in the table LAMPROP (A11, A12, A16, A22, A26, and A66), along with the following material properties: elastic moduli in the major and minor directions (E1 and E6), shear modulus (G12), Poisson's ratio (NU21), and thermal expansion coefficients (ALP1 and ALP2). Again, the derivation for each of these values is given in Appendix 7. The identification code, laminate code, and unidirectional composite code for the laminate are placed in the table LAMINATE.

5.6 Files

The *Files* option of the CDI main menu allows the user to create files of material data suitable for use with either the ANSYS finite element analysis program [2] or with the MAZE preprocessor for the DYNA2D and NIKE2D analysis codes [4]. Several material data files, associated with data transfer into both ANSYS and MAZE, are included in Appendix 4 for reference. In addition, Section 6 demonstrates the use of the entire CDI system with a complete example. Selecting the *Files* option calls the FILES.CMD program and generates the following menu, listing the types of interface files available.

```
*** GENERATE INTERFACE FILES (Select applicable analysis program) ***
   ANSYS      MAZE      INGRID      Exit
```

Note that the *INGRID* option indicates a future capability of the CDI, generation of files suitable for use with the INGRID program. Because this menu option currently initiates no action, it is not discussed any further in this manual.

5.6.1 ANSYS Files

Selecting the *ANSYS* option from this menu creates a file of material data known as an ANSYS User file, which is stored on the current disk drive and directory. The CDI programs associated with the ANSYS files application are ANSFILE.CMD, ANSUNI.CMD, ANSLAM.CMD, UNINAME.CMD, LAMNAME.CMD, FIX.CMD, T2.CMD, T4.CMD, D_BLOCK.CMD, and ANSFGEN.CMD.

To generate an interface file using the *ANSYS* option, the user must specify a User file name of up to eight characters with a three character extension, and he must identify each material to be defined in a data block contained therein. The following discussion describes the function and proper use of this option.

ANSYS can be run in two modes, batch and interactive. When ANSYS is run in batch mode, a batch input file must first be created which contains the element mesh and loading geometry. This batch input file is created outside of the CDI. However, the User file, containing the material data obtained from the database, must be properly referenced by embedding the commands listed below within the batch file.

The User file acts as a library file into which arguments can be passed from the ANSYS batch input file. This allows the User file to be created once, with the CDI, and used wherever applicable in ANSYS. The User file consists of any number of data blocks; each data block is identified by a name and contains appropriate material property definitions of one database material, which is selected by the user.

The data block name, which is also specified by the user, should identify the material defined within that block. Each data block is automatically prepared within the CDI program in such a way that the material properties of one composite can be assigned to a range of ANSYS material numbers.

To properly identify the User file, the *UFILE command must be placed in the beginning of the batch input file. The syntax for this command is:

```
*UFILE filename,extension
```

where *filename* is the User file name (up to eight characters) and extension is the file extension (up to three characters).

To use a material data block in the User file as the material property definition for one or more ANSYS material numbers, the *USE command is employed. The command syntax is:

```
*USE datablock,mat.no.a,mat.no.b,increment
```

where *datablock* is the name of the material data block from which to retrieve data on materials number *mat.no.a* through *mat.no.b*, incremented by *increment*.

The data items needed to generate a data block for analysis of an axisymmetric solid are EX, EY, EZ, NUXY, NUYZ, ALPZ, ALPY, ALPZ, GXY, GYZ, and GXZ. Naturally, for a two-dimensional plane solid only properties in two dimensions are required. These data items will come from different database tables depending on whether the material being defined is a unidirectional or laminated composite. If certain properties are not in the database, the user will be prompted to either enter an approximate value (which is used only for the file definition and is not placed into the database) or abort the file generation.

5.6.2 MAZE Files

Selecting the *MAZE* option from the *Generate Interface Files* menu creates a material data file to be merged with a MAZE batch input file. To do this, the MAZFILE.CMD program is initiated, which in turn accesses the following routines: MAZUNI.CMD, MAZLAM.CMD, UNINAME.CMD, LAMNAME.CMD, FIX.CMD, T2.CMD, T4.CMD, and MAZFGEN.CMD. The user must provide a name for the data file and an identification for each material to be defined therein.

The MAZE material data file cannot stand alone like the ANSYS User file. Instead, it must be merged into an existing MAZE batch input file with a text editor. Materials are defined within the CDI by a material number rather than by an eight character name. Each reference to this material within the batch input file must use this same material number.

Once a new material data file is created, it is stored on the active disk drive and directory. The following data items must be available in the database to create a complete material definition: EX(EA), EY(EB), EZ(EC), NUYX(PRBA), NUZY(PRCB), NUZX(PRCZ), DENS(RO), and GXY(GAB). The property names in parentheses are the MAZE property labels, while the names preceding the parentheses refer to the corresponding database field names for a unidirectional composite.

As with ANSYS, both unidirectional and laminated materials can be defined; data will be taken from the appropriate database tables. If data values are not available in the database, the user will be prompted to enter them or abort processing.

Again, refer to Appendix 4 to see several example files of both MAZE and ANSYS input.

6 SYSTEM DEMONSTRATION WITH EXAMPLE

To illustrate several capabilities of the CDI system and how each is used, a complete example problem is presented. The example is designed to be as realistic as possible, while illustrating the exact commands, prompts, and user responses involved. The situation is first presented as a sample problem in the following subsection, then each main menu option is illustrated.

6.1 Problem Statement

The user wishes to perform finite element analysis, using ANSYS and MAZE, on a composite material structure. The material, T300/5208, a carbon fiber reinforced composite, has the following properties, which are first stored in the database using the *Enter Database Data* option of the *Database Actions* menu:

Elastic modulus in fiber direction (Ex): 26.3E6 psi
Elastic modulus in transverse direction (Ey): 1.49E6 psi
Shear modulus of elasticity (Gxy): 1.04E6 psi
Major Poisson's ratio (NUyx): .28
Density (DENS): 30.8E-6 lbf-s^2/in
Major thermal expansion coef. (ALPx): 0.02E-6 in/in-° C
Minor thermal expansion coef. (ALPy): 22.5E-6 in/in-° C

The composite structure is to be tested in several configurations, using both a laminate and as a unidirectional composite. Therefore, material property data on the laminate must also be generated and stored in the database using the *Laminate* option of the CDI.

The user can edit or delete any data with the *Modify Database Data* option of the *Database Actions* menu, or print a report using the main menu *Reports* option. Finally, using the *Files* option, he must be able to create material data files suitable for use with either ANSYS or MAZE.

Each option of the CDI system is discussed within the context of this example. Note, however, that the options are not described in the same order as they appear on the CDI main menu.

6.2 Starting the Program

The Composites Database Interface, as described in the previous section, is started by typing the following command in the R:BASE command mode.

```
R>RUN COMP.CMD
```

An introductory screen first appears; the main menu will appear after any key is pressed. For further information about accessing the CDI main menu or starting R:BASE, refer to Sections 4 and 5.

6.3 Database Actions

The *Database* option of the CDI main menu should be selected to enter or edit database data. This option is also used to execute data manipulation commands directly using the R:BASE **Prompt By Example** mode. The use of all three of these options is illustrated within this section.

6.3.1 Data Entry

As indicated above, to enter the composite property data into the database, first select the *Database* option from the CDI main menu. The *Database Actions* menu then appears, from which the first option, *Enter Database Data*, should be chosen. A third menu will then appear on the screen, as illustrated below.

*** ENTER DATABASE DATA (Select a data category) ***

(1) Unidirectional composites
(2) Laminated composites
(3) Exit to previous menu

This menu displays the types of composites data which may be entered. Again, select option one to enter data on unidirectional composites. A prompt appears beneath the menus requesting the composite name; type "**T300/5208**." If this composite had previously been entered a message would have suggested appropriate actions; otherwise, the user is prompted to enter an identification code. Any previously unused ID code is sufficient, although a "U" followed by a real number is suggested.

Upon properly entering both the composite name and ID code, a data entry form will appear on the screen. This form corresponds to the UNICOMP table. Fill in the empty fields such that the form resembles the following illustration.

UNIDIRECTIONAL COMPOSITE MATERIALS

IDENTIFICATION CODE: U1

COMPOSITE NAME: T300/5208

TYPE OR CLASS: CFRP

FIBER: T300

MATRIX: N5208

FORM IN WHICH THE PRODUCT IS AVAILABLE: Tape or cloth

PROCESSING WHICH THE COMPOSITE HAS UNDERGONE: Autoclave

After all data items have been entered, press [Esc]. A small menu should appear across the top of the screen. Select *Add* to enter the row of data into the database. (The remaining options are discussed in the previous section.) A short pause will follow, then a second data entry form appears, corresponding to the UNIPROP table.

The property data values given previously should be typed into the corresponding empty fields on this form. When complete, the form should resemble the following figure. Note that the shear modulus of elasticity was entered as 7.04E6 rather than 1.04E6. This error was made intentionally, so that the data editing capabilities may later be illustrated.

UNIDIRECTIONAL COMPOSITE MATERIALS

IDENTIFICATION CODE: U1	FIBER: T300
COMPOSITE NAME: T300/5208	MATRIX: N5208
CLASS: CFRP	

ELASTIC MODULI:	THERMAL EXPANSION COEF.:
EX: 2.63E7 (psi)	ALPX: 2.E-8 (in/in-° C)
EY: 149000. (psi)	ALPY: 2.25E-5 (in/in-° C)
POISSON'S RATIOS:	SHEAR MODULI OF ELASTICITY:
NUYX (MAJOR): 0.28	GXY: 7.04E6 (psi)
NUXY (MINOR): 0.015863	

DENSITY: 3.08E-5 (lbf-s^2/in^4 = lbf/in^3 ÷ 386.4 in/s^2)

Again, press [Esc] and select *Add* from the resulting menu to enter this row into the database. The appropriate menus for this action again appear on the screen, along with the following prompt.

NAME OF NEXT COMPOSITE TO ENTER (TYPE [ENTER] TO QUIT):

Press either [ENTER] or [Esc] to return control to the *Enter Database Data* menu. Continue by selecting the appropriate item from this menu.

6.3.2 Data Modification

To change current data values in a table or to delete an existing row from the database, choose the second option, *Modify Database Data*, from the *Database Actions* menu. Another menu will appear beneath the current one; select option one, *Unidirectional Data*, to edit the incorrect data entered previously. The user will then be prompted for the composite name; type "**T300/5208**."

A data editing form will soon appear on the screen. Notice that the data contained therein is identical to that entered into the UNICOMP table for this row. As all of these values were entered correctly, no changes need to be made. Press [Esc] from the menu at the screen top and the second data editing form, corresponding to the UNIPROP table, will appear.

Choose *Edit* from the small menu and the highlight cursor will move down into the form. Place that cursor over the incorrect data in the shear modulus field (7,040,000) and type the new value (1,040,000 or 1.04E6). If there are no other changes to be made, press [Esc] to return to the menu. Enter the changes into the database by selecting *Save*. The form should now resemble the following illustration.

UNIDIRECTIONAL COMPOSITE MATERIALS

IDENTIFICATION CODE: U1	FIBER: T300
COMPOSITE NAME: T300/5208	MATRIX: N5208
CLASS: CFRP	

ELASTIC MODULI:
EX: 2.63E7 (psi)
EY: 149000. (psi)

THERMAL EXPANSION COEF.:
ALPX: 2.E-8 (in/in-° C)
ALPY: 2.25E-5 (in/in-° C)

POISSON'S RATIOS:
NUYX (MAJOR): 0.28
NUXY (MINOR): 0.015863

SHEAR MODULI OF ELASTICITY:
GXY: 1040000 (psi)

DENSITY: 3.08E-5 (lbf-s^2/in^4 = lbf/in^3 ÷ 386.4 in/s^2)

To exit the form, choose *Quit*. Other menu options are discussed in the previous section on running the program. Again, the user will be prompted to enter another composite name or type [ENTER] to quit.

6.3.3 Entering R:BASE Directly

The third option on the *Database Actions* menu allows the user to enter the R:BASE **Prompt By Example** (**PBE**) mode directly. The user might select this option to perform any number of R:BASE commands. As an example, consider querying the database for a unidirectional composite with a major stiffness, EX, of 26.3E6 psi.

From the *Database Actions* menu, the user must first select option three, *Enter R:BASE Directly*. The following message appears on the screen.

PRESS ANY KEY TO ENTER THE R:BASE PROMPT BY EXAMPLE (PBE)
MODE. TO RETURN FROM PBE TO THE DATABASE ACTIONS MENU,
PRESS [ESC] AT THE PBE MAIN MENU SCREEN.

Press any key to enter the **PBE** mode. The **PBE** main menu shown below, lists various operations which can be performed.

R:BASE
Prompt By Example
Copyright (c) Microrim, Inc.,1987

(1) Define or modify a database
(2) Create or modify an R:BASE application
(3) Open an existing database
(4) Add data to a database
(5) Modify data
(6) Query a database
(7) SQL (Structured Query Language) commands
(8) Exit from R:BASE

For this example problem, select option 6 to query the database. At the next screen, choose the first option, *Look at Data*.

At this point, the user must define the R:BASE command using the prompt information given on each screen. The first screen lists and describes various available commands. Choose *SELECT* to view data on the screen. At the next screen, listing tables, indicate that data should be selected from UNIPROP. For simplicity, select *(All)* columns at the next prompt.

The data does not need to be sorted, therefore press [ESC] at the following prompt. Finally, the condition must be described. By answering each prompt appropriately, indicate that the data should include those rows where EX equals (EQ) 26.3E6 psi. Select *(Done)* from the menu of operators to end the command definition. When the command is complete and accurate, select *Execute* to view the selected data. Upon execution of the command, the screen should appear as shown below.

SELECT ALL FROM UNIPROP WHERE EX EQ 26.3E6

UNID	EX	EY	ALPX	ALPY	NUYX	NUXY	DENS
U1	2.63E7	1490000.	2.E-8	2.25E-5	0.28	0.015863	3.08E-5

To exit **PBE** from any point, press [ESC] until the *Database Actions* menu appears on the screen. As can be seen from the above discussion, using **PBE** requires at least a basic knowledge of the database and of the available R:BASE commands. In addition, some database operations should be avoided as they will alter the database structure or data incorrectly.

6.4 Getting Help

Help screens are available for most menu options, such as designing a laminate, for example. To view context sensitive help on designing laminates, first select the *Help* option from the CDI main menu. A second menu, shown below, will appear that lists the various topics on which help is available.

*** HELP MENU (Select a topic for help menus or screens) ***

DATABASE VIEWS REPORTS LAMINATE FILES ANALYSIS EXIT

From this menu, choose the *Laminate* option; the following screen will appear.

The LAMINATE option of the Composites Database Interface allows the user to define either quasi-isotropic or general laminates from the unidirectional composite data stored in the database.

As input, the user must provide the name of the unidirectional composite and the laminate code for the laminated composite to be generated. A laminate code should have the following structure:

[orient(vol)/orient(vol)...]factor

where "orient" and "vol" are the orientation and volume fraction of each layer in the laminate. Orientations are entered in degrees with counter-clockwise angles positive; volume fraction is a dimensionless quantity. "Factor" is an optional parameter which indicates that the laminate code represents only a portion of the layup, a sublaminate. An "S" *indicates that the sublaminate is* repeated symmetrically; a digit represents the number of repeating sublaminates in the layup.

More output follows - press [ESC] to quit, any key to continue

Selecting the LAMINATE option places both normalized laminate stiffness properties and on-axis material properties for the new laminate into the database, along with the proper identifying information.

PRESS ANY KEY TO CONTINUE

As the messages on the screen indicate, pressing the correct keys will cause appropriate actions to occur. After the menu is displayed, pressing a key clears the screen and causes the previous menu to reappear.

6.5 Designing a Laminate

To design a laminate and generate its material properties from the corresponding unidirectional composite, select the *Laminate* option from the CDI main menu. In this illustration, two laminates will be defined from the unidirectional composite T300/5208. First, a quasi-isotropic laminate will be generated, then one with a [0(2)/45/-45] laminate code. The latter will be used in demonstrating the file generation capacities of the CDI.

To design one or more laminates using the *Laminate* option, the user must simply give correct responses to several on-screen prompts. For this reason, the remainder of this subsection will be a simulation of these prompts in sans serif capital letters followed by appropriate user responses in typewriter font. Most queries are self-explanatory; however, comments have been interspersed where deemed necessary.

ENTER THE NAME OF THE UNIDIRECTIONAL COMPOSITE IN THIS LAMINATE.
(TYPE [ENTER] TO LIST ALL UNIDIRECTIONAL COMPOSITES): `T300/5208`

DO YOU WISH TO DESIGN A QUASI-ISOTROPIC LAMINATE? (Y/N) `Y`

ENTER AN ID CODE FOR THE LAMINATE IN THIS FORM: L1, L2.
(TYPE [ENTER] TO LIST ALL CURRENTLY USED ID CODES): `L10`

For a quasi-isotropic laminate, there is not need to enter a laminate code. Refer to Section 5.5 for more information. After a brief pause, the quasi-isotropic laminate is generated and the following screen appears:

THE TOTAL STIFFNESS MATRIX FOR THIS COMPOSITE IS:

```
1.41E7   2.84E5   0.0000
2.84E5   1.41E7   0.0000
0.0000   0.0000   6.9E6
```

E(iso) = 14086805 G(iso) = 6904483 NU(iso) = 0.02

QUASI-ISOTROPIC DATA LOADED INTO DATABASE.
PRESS ANY KEY TO CONTINUE. [**ENTER**]

DESIGN ANOTHER LAMINATE USING THIS COMPOSITE? (Y/N) **Y**

As indicated on the screen, the material properties for the quasi-isotropic laminate have now been entered into the database. To design the second, general laminate, respond affirmatively to the above prompt. Continue entering information as described below.

ENTER AN ID CODE FOR THE LAMINATE IN THIS FORM: L1, L2.
(TYPE [ENTER] TO LIST ALL CURRENTLY USED ID CODES): **L11**

ENTER THE LAMINATE CODE IN THIS FORM: [0(2)/90]S, [45/-45]2
[0(2)/45/-45]

Refer to the previous section, entitled **Running the Program**, for an explanation of laminate codes. Be sure to enter the laminate code correctly because this code is used to generate the laminate. Again, there is a short pause while material property data for the laminate is generated from the laminate code. This information is displayed on the following screen.

THE TOTAL STIFFNESS MATRIX FOR THIS LAMINATE IS:

```
2.03E7   2.84E5   22.
2.84E5   7.86E6   22.
22.      22.      6.9E6
```

E1 = 2.0312E7 E2 = 7858369. G12 = 6904440. NU21 = 0.036

WHERE "1" IS THE MAJOR AXIS (0° ROTATION) AND "2" IS THE MINOR.

DATA FOR THIS LAMINATE IS NOW LOADED INTO THE DATABASE.
DESIGN ANOTHER LAMINATE USING THIS COMPOSITE? (Y/N) **N**

DESIGN A LAMINATE USING ANOTHER UNIDIRECTIONAL COMPOSITE? (Y/N) **N**

Enter a negative response to the above two prompts to stop defining laminates. The laminate property data is now stored in the database and may be edited, deleted, viewed, or used to create material data files.

6.6 Views and Reports

Views and reports can be very useful in compiling and presenting data from the database. The user might wish to know, for example, what laminates have been designed using T300/5208, the composite material described above. To see this information on the screen, select *Views* from the CDI main menu. Choose *Reports* and set up the printer to print a hard copy of the data. Selecting *Views* will cause a menu resembling the following to appear. (If the user is printing hard copy reports, the menu title will indicate this.)

```
=============== *** VIEW DATA ON SCREEN  (Select a data category) *** ===============
                        (1) Unidirectional composites
                        (2) Laminated composites
                        (3) Exit to previous menu
```

To see a view detailing laminates, select the second option, *Laminated Composites*, from this menu. A third menu will appear listing the types of report available. This menu is illustrated below.

```
=============== *** TYPE OF REPORT/VIEW  (Select a data category)*** ===============
                  (1) Identification report (ID no., class, fiber, etc.)
                  (2) Material property report (ID no., EX, EY, etc.)
                  (3) Exit to previous menu
```

For space considerations, the less complex identification report, option 1, will be shown here. After this selection is made, the fourth and final menu appears. This menu, illustrated below, allows the user to either view data on all laminates in the database or on a subset of laminates designed from a specific composite.

```
=============== *** SEARCH CATEGORIES (Select appropriate category) *** ===============
                        (1) View by composite name
                        (2) View all laminates
                        (3) Exit to previous menu
```

Because the user wishes to see which laminates have been designed using T300/5208, option 1, *View By Composite Name*, should be selected. After a short pause, a list of composite materials used in designing laminates will appear. At this point the screen will appear as shown below.

```
UNINAME
-------
AS/H3501
T300/5208

SELECT A COMPOSITE: T300/5208
```

Type "**T300/5208**" at the prompt and the report will soon be generated. As expected, it includes the two laminates which were designed in the previous step on generating a laminate. Had the user chosen a material property report, he could have verified the property data shown on-screen for each laminate as it was defined. The identification report is illustrated below.

LAMINATED COMPOSITE MATERIALS

LAM. ID	LAMINATE CODE	UNI. COMPOSITE
L10	QUASI-ISO	T300/5208
L11	[0(2)/45/-45]	T300/5208

If an on-screen view was selected, press any key to return to the *Search Categories* menu. Control returns automatically after a hard copy report is generated.

6.7 Creating Data Files

To create a data file for transferring material property data to a FEA program, select the *Files* option of the CDI main menu. The following menu will appear, enumerating the types of data files which can be generated.

```
*** GENERATE INTERFACE FILES (Select applicable analysis program) ***
    ANSYS      MAZE      INGRID      Exit
```

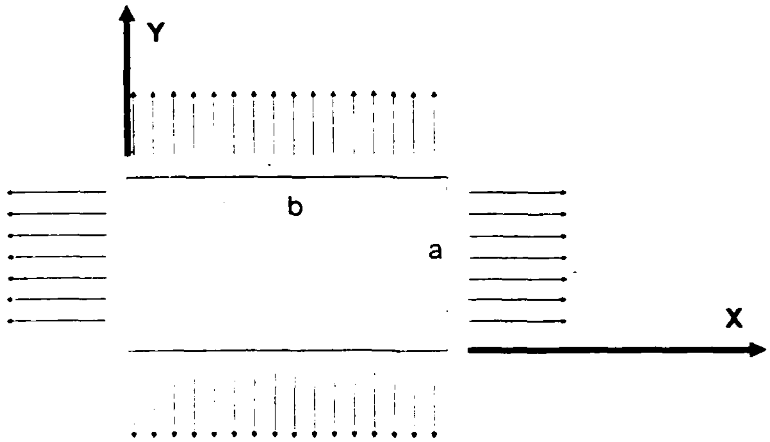
The following subsections illustrate the use of each option.

6.7.1 Creating ANSYS Data Files

There are several steps involved in performing finite element analysis on a composite material using ANSYS. Initially, a batch input file must be generated which contains the finite element mesh and the loading geometry. This file must also contain the proper references to the User file, which contains data blocks of material property data.

For more information on the composition and relationship of the batch input and User files, refer to the previous section, entitled **Running the Program.** The remainder of this subsection describes the creation of several sample input files. Each illustrates a different capacity of the ANSYS file generation program.

For the first three examples, consider designing a two dimensional rectangular solid having a large horizontal (x) load and a smaller vertical (y) load. This geometry and loading detail, which would be contained in the batch input file, is illustrated below.



In an attempt to find an appropriate configuration of the composite T300/5208, a User file will be created with data blocks for the following three material configurations.

- Unidirectional composite with the fiber aligned on the x-axis.
- Unidirectional composite with the fiber at 30 degrees counter-clockwise from the x-axis.
- Four ply laminate with the following laminate code: [0(2)/45/-45].

To initiate the file development process, select the ANSYS option from the *Generate Interface Files* menu. Following are the screen prompts and user responses necessary to develop this file. Brief comments are included to clarify the text.

ENTER A NAME FOR THE ANSYS USER FILE: **ANS2_D.SPL**

HOW MANY UNIDIRECTIONALS TO BE DEFINED? **2**
HOW MANY LAMINATES TO BE DEFINED? **1**

In defining the material configuration for a unidirectional composite, the composite must be identified (T300/5208), and its orientation with respect to the ANSYS axes must be indicated (two-dimensional solid, zero degrees rotation).

ENTER THE NAME OF UNIDIRECTIONAL COMPOSITE NUMBER 1 OF 2.
(TYPE [ENTER] TO LIST ALL UNIDIRECTIONALS): **T300/5208**

THE DATA BLOCK NAME FOR MATERIAL T300/5208 MUST BE EIGHT
OR FEWER CHARACTERS. ENTER A NEW DATA BLOCK NAME: **UNI-0**

TYPE [P] IF DEFINING A 2-DIMENSIONAL PLANE SOLID IN THE
X-Y PLANE; TYPE [A] IF DEFINING AN AXISYMMETRIC SOLID WITH
SYMMETRY AROUND THE Y-AXIS IN THE Z-DIRECTION. **P**

ENTER THE ANGLE BY WHICH THE COMPOSITE FIBER DIRECTION IS ROTATED
FROM THE ANSYS GLOBAL X-AXIS (COUNTER-CLOCKWISE POSITIVE): **0**

CREATING ANSYS DATA BLOCK...

IF DESIRED, ENTER A COMMENT LINE TO BE ADDED TO THE DATA
BLOCK DESCRIBING THE MATERIAL; TYPE [ENTER] FOR NONE
>**T300/5208 UNIDIRECTIONAL W/ FIBER IN X-DIRECTION (ZERO DEGREES)**

DATA BLOCK COMPLETE. PRESS ANY KEY TO CONTINUE. [**ENTER**]

ENTER THE NAME OF UNIDIRECTIONAL COMPOSITE NUMBER 2 OF 2.
(TYPE [ENTER] TO LIST ALL UNIDIRECTIONALS): **T300/5208**

THE DATA BLOCK NAME FOR MATERIAL T300/5208 MUST BE EIGHT
OR FEWER CHARACTERS. ENTER A DATA BLOCK NAME: **UNI-30**

TYPE [P] IF DEFINING A 2-DIMENSIONAL PLANE SOLID IN THE
X-Y PLANE; TYPE [A] IF DEFINING AN AXISYMMETRIC SOLID WITH
SYMMETRY AROUND THE Y-AXIS IN THE Z-DIRECTION. **P**

ENTER THE ANGLE BY WHICH THE COMPOSITE FIBER DIRECTION IS ROTATED
FROM THE ANSYS GLOBAL X-AXIS (COUNTER-CLOCKWISE POSITIVE): **30**

CREATING ANSYS DATA BLOCK...

IF DESIRED, ENTER A COMMENT LINE TO BE ADDED TO THE DATA
BLOCK DESCRIBING THE MATERIAL; TYPE [ENTER] FOR NONE.
>**T300/5208 UNIDIRECTIONAL W/ FIBER AT 30 DEGREES CCW FROM X-AXIS**

DATA BLOCK COMPLETE. PRESS ANY KEY TO CONTINUE. [**ENTER**]

Defining a laminate is similar to defining a unidirectional composite. The laminate must be identified by its identification code (L11) and its orientation with respect to the ANSYS axes (in a two dimensional plane) must be specified. One difference, however, is that a laminate may not be rotated to fit a particular coordinate system, as was done with the unidirectional composite in the previous example. As indicated by the note on the screen shown below, if a proper orientation does not exist in the database, it must be defined before the material data block is created.

ENTER THE ID CODE OF LAMINATED COMPOSITE NUMBER 1 OF 1...
NOTE: IF THE ANSYS/MAZE GLOBAL COORDINATE SYSTEM IS DIFFERENT
THAN THE MAJOR AND MINOR AXES OF THE LAMINATE YOU WISH TO USE,
YOU MUST EXIT THIS ROUTINE AND USE "LAMINATE" TO DEFINE A NEW
LAYUP WITH THE PROPER ORIENTATION. ALL PREVIOUSLY DEFINED
MATERIALS WILL BE SAVED. FOR EXAMPLE, IF A [0/90] LAMINATE IS
TO BE SITUATED AT A 7 DEGREE ANGLE FROM THE GLOBAL X-AXIS, DEFINE
A [7/97] LAMINATE INSTEAD. QUASI-ISOTROPIC LAMINATES DO NOT NEED
TO BE ORIENTED AT ANY PARTICULAR ANGLE.

TYPE [E] TO USE AN EXISTING LAMINATE; TYPE [D] TO EXIT AND DEFINE
A NEW ONE. TYPE [ENTER] TO LIST CURRENT LAMINATES. **E**

ENTER THE LAMINATE ID CODE: **L11**

SHOULD THE DATA BLOCK NAME FOR L11 BE DIFFERENT THAN
THE PREVIOUSLY ENTERED NAME/ID CODE? (Y/N): **Y**

ENTER A DATA BLOCK NAME (UP TO EIGHT CHARS): **LAM1**

TYPE [P] IF DEFINING A 2-DIMENSIONAL PLANE SOLID IN THE
X-Y PLANE; TYPE [A] IF DEFINING AN AXISYMMETRIC SOLID WITH
SYMMETRY AROUND THE Y-AXIS IN THE Z-DIRECTION. **P**

IF DESIRED, ENTER A COMMENT LINE TO BE ADDED TO THE DATA
BLOCK DESCRIBING THE MATERIAL; TYPE [ENTER] FOR NONE.
>LAMINATE [0(2)/45/-45] FROM T300/5208

DATA BLOCK COMPLETE. PRESS ANY KEY TO CONTINUE. [**ENTER**]

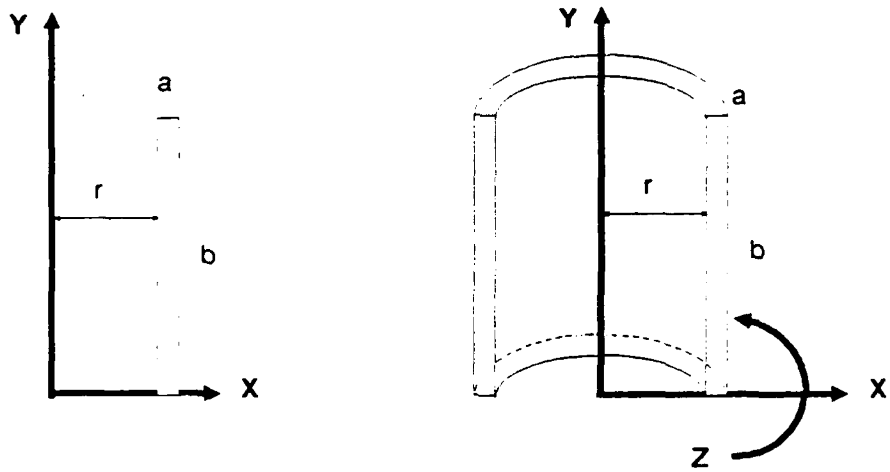
FILE GENERATION COMPLETE. PRESS ANY KEY TO CONTINUE. [**ENTER**]

At this point, all three data blocks have been defined and control returns to the *Generate Interface Files* menu, which displays the available file types. To view the file, exit the CDI program and enter the following command at the R> prompt.

R>**TYPE ANS2_D.SPL**

The three data blocks in this file, as well as the one yet to be defined, are included in Appendix 4 for reference.

The data blocks defined thus far deal exclusively with two dimensional plane solids. The other capacity included within the system is the ability to define three dimensional axisymmetric solids; this is the focus of the fourth ANSYS example. An axisymmetric shape is defined in the same way as a plane solid, except that the two-dimensional element is rotated around the y-axis, creating a 3-dimensional shape. A typical axisymmetric shape, and its two dimensional representation, is illustrated below.



There are two types of axisymmetric solids commonly associated with composite materials: hoop-wound and radial. A hoop-wound composite, such as the one in the previous illustration, has either fibers or layups in the hoop direction, at some angle to the z, or hoop axis. The x, or radial axis, therefore, has the properties of the weakest direction of the composite.

A radial composite has fibers or layups positioned along the radial axis of the solid, like spokes out from a hub. Again, these fibers or laminates may be at any angle from the horizontal.

The current scope of the Composites Database encompasses two dimensional unidirectional and laminate property data. To completely define an axisymmetric or three dimensional solid, a third dimension of data is required. Simply stated, properties through the thickness of a laminate or unidirectional composite are required.

Currently, these values are not readily available because they can only be approximated or generated through testing. As such, they are not included in the database. A data file can be generated to model an axisymmetric solid, however. The missing data values are marked with asterisks to be filled in by the user at a later time.

As an example, consider making the above hoop-wound cylinder out of the same composite used previously, T300/5208, wrapped at a thirty degree angle to the z-axis. The appropriate user responses to define this material model are shown below.

ENTER A NAME FOR THE ANSYS USER FILE: **ANS_AXI.SPL**

HOW MANY UNIDIRECTIONALS TO BE DEFINED? **1**
HOW MANY LAMINATES TO BE DEFINED? **0**

ENTER THE NAME OF UNIDIRECTIONAL COMPOSITE NUMBER 1 OF 1.
(TYPE [ENTER] TO LIST ALL UNIDIRECTIONALS): **T300/5208**

THE DATA BLOCK NAME FOR MATERIAL T300/5208 MUST BE EIGHT
OR FEWER CHARACTERS. ENTER A DATA BLOCK NAME: **HW.U-30**

TYPE [P] IF DEFINING A 2-DIMENSIONAL PLANE SOLID IN THE
X-Y PLANE; TYPE [A] IF DEFINING AN AXISYMMETRIC SOLID WITH
SYMMETRY AROUND THE Y-AXIS IN THE Z-DIRECTION. **A**

TYPE [H] IF COMPOSITE IS HOOP-WOUND; TYPE [R] FOR RADIAL. **H**

```
ENTER THE ANGLE BY WHICH THE COMPOSITE FIBER DIRECTION IS ROTATED
FROM THE ANSYS GLOBAL Z-AXIS (COUNTER-CLOCKWISE POSITIVE): 30

CREATING ANSYS DATA BLOCK...

IF DESIRED, ENTER A COMMENT LINE TO BE ADDED TO THE DATA
BLOCK DESCRIBING THE MATERIAL; TYPE [ENTER] FOR NONE.
>T300/5208 UNI. HOOP-WOUND W/ FIBER AT 30 DEGREES CCW FROM
Z-AXIS

DATA BLOCK COMPLETE. PRESS ANY KEY TO CONTINUE. [ENTER]
```

To view the file, exit the CDI program and type the following command:

```
A>TYPE ANS_AXI.SPL
```

Again, refer to Appendix 4 to see the actual ANSYS data file.

6.7.2 Creating MAZE Data Files

Performing finite element analysis with MAZE is similar in many ways to performing an ANSYS analysis. Solid geometry, loading conditions, and material properties must all be defined prior to analysis. One primary difference is that the material data file generated with the CDI must be physically merged with the batch input file using a text editor.

Further information regarding the creation and use of the MAZE material data and batch input files is available in the previous section, *Running the Program*. The remainder of this subsection illustrates the generation of several example input files. So that a comparison may be made between the ANSYS and MAZE files, the same problem definition is presented here.

The first three sample files will pertain to a two dimensional rectangular solid with a large horizontal load and a smaller vertical load. The fourth and final example refers to a hoop-wound axisymmetric cylinder. Appropriate figures may be found in the previous subsection.

The four material configurations, each using T300/5208, are repeated here.

- Unidirectional composite with the fiber aligned on the x-axis.
- Unidirectional composite with the fiber at 30 degrees counter-clockwise from the x-axis.
- Four ply laminate with the following laminate code: [0(2)/45/-45]. The x-axis corresponds to zero rotation.
- Unidirectional composite hoop-wound with the fiber at 30 degrees counter-clockwise from the hoop or z-axis.

To initiate the file generation process, the *MAZE* option should be selected from the *Generate Interface Files* menu. As with defining material property data for ANSYS analysis, the remainder of the routine consists of giving the correct responses to on-screen prompts.

In this example, all four material definitions will be placed in the same ASCII file. The placement order of the material property data into the ASCII file is irrelevant as long as each material definition is properly merged with the appropriate batch input file. Placement within the ASCII file does, however, affect the material numbering convention: each material defined within a single ASCII file is numbered consecutively in the order that they are defined, starting with material number one. This too can be altered with the text editor if necessary.

Following are the screen prompts and appropriate user responses to develop this file. Because of program constraints, the three unidirectional composites, including the hoop-wound composite, will be defined before the laminate is defined.

ENTER A NAME FOR THE MAZE USER FILE: **MAZE.SPL**

HOW MANY UNIDIRECTIONALS TO BE DEFINED? **3**
HOW MANY LAMINATES TO BE DEFINED? **1**

NOTE: MATERIALS WILL BE NUMBERED CONSECUTIVELY FROM 1 TO 4
IN THE ORDER THAT THEY ARE DEFINED. PLEASE ENSURE THAT THIS
IS CONSISTENT WITH THE NUMBERING CONVENTION USED ELSEWHERE IN
THE MAZE INPUT FILE. PRESS ANY KEY TO CONTINUE. [**ENTER**]

ENTER THE NAME OF UNIDIRECTIONAL COMPOSITE NUMBER 1 OF 3.
(TYPE [ENTER] TO LIST ALL UNIDIRECTIONALS): **T300/5208**

TYPE [P] IF DEFINING A 2-DIMENSIONAL PLANE SOLID IN THE
X-Y PLANE; TYPE [A] IF DEFINING AN AXISYMMETRIC SOLID WITH
SYMMETRY AROUND THE Y-AXIS IN THE Z-DIRECTION. **P**

CREATING MAZE DATA BLOCK...

ENTER THE ANGLE BY WHICH THE COMPOSITE FIBER DIRECTION IS ROTATED
FROM THE MAZE GLOBAL X-AXIS (COUNTER-CLOCKWISE POSITIVE): **0**

ENTER A HEADING FOR THIS MATERIAL DEFINITION OF EIGHTY OR FEWER
CHARACTERS, OR TYPE [ENTER] TO ACCEPT DEFAULT HEADING.
>**T300/5208 UNIDIRECTIONAL W/ FIBER IN X-DIRECTION (ZERO DEGREES)**

ENTER HOURGLASS "Q" (0.0 < q < 0.1): **0.06**

Note that 0.06 is the default value for the hourglass coefficient. A second way to enter the default value is to simply type [ENTER] at the previous prompt.

DATA BLOCK COMPLETE. PRESS ANY KEY TO CONTINUE. [**ENTER**]

ENTER THE NAME OF UNIDIRECTIONAL COMPOSITE NUMBER 2 OF 3.
(TYPE [ENTER] TO LIST ALL UNIDIRECTIONALS): **T300/5208**

TYPE [P] IF DEFINING A 2-DIMENSIONAL PLANE SOLID IN THE
X-Y PLANE; TYPE [A] IF DEFINING AN AXISYMMETRIC SOLID WITH
SYMMETRY AROUND THE Y-AXIS IN THE Z-DIRECTION. **P**

ENTER THE ANGLE BY WHICH THE COMPOSITE FIBER DIRECTION IS ROTATED
FROM THE MAZE GLOBAL X-AXIS (COUNTER-CLOCKWISE POSITIVE): **30**

CREATING MAZE DATA BLOCK...

ENTER A HEADING FOR THIS MATERIAL DEFINITION OF EIGHTY OR FEWER

CHARACTERS, OR TYPE [ENTER] TO ACCEPT DEFAULT HEADING.
>**T300/5208 UNIDIRECTIONAL W/ FIBER AT 30 DEGREES CCW FROM X-AXIS**

ENTER HOURGLASS "Q" (0.0 < q < 0.1): **0.06**

DATA BLOCK COMPLETE. PRESS ANY KEY TO CONTINUE. [**ENTER**]

ENTER THE NAME OF UNIDIRECTIONAL COMPOSITE NUMBER 3 OF 3.
(TYPE [ENTER] TO LIST ALL UNIDIRECTIONALS): **T300/5208**

TYPE [P] IF DEFINING A 2-DIMENSIONAL PLANE SOLID IN THE
X-Y PLANE; TYPE [A] IF DEFINING AN AXISYMMETRIC SOLID WITH
SYMMETRY AROUND THE Y-AXIS IN THE Z-DIRECTION. **A**

TYPE [H] IF COMPOSITE IS HOOP-WOUND; TYPE [R] FOR RADIAL. **H**

ENTER THE ANGLE BY WHICH THE COMPOSITE FIBER DIRECTION IS
ROTATED FROM THE MAZE GLOBAL HOOP DIRECTION (Z-AXIS).
CONSIDER COUNTER-CLOCKWISE TO BE POSITIVE: **30**

ENTER A HEADING FOR THIS MATERIAL DEFINITION OF EIGHTY OR FEWER
CHARACTERS, OR TYPE [ENTER] TO ACCEPT THE DEFAULT HEADING.
>**T300/5208 UNI. HOOP-WOUND W/ FIBER AT 30 DEGREES CCW FROM Z-AXIS**

ENTER HOURGLASS "Q" (0.0 < Q < 0.1): **0.06**

DATA BLOCK COMPLETE. PRESS ANY KEY TO CONTINUE. [**ENTER**]

ENTER THE ID CODE OF LAMINATED COMPOSITE NUMBER 1 OF 1...
NOTE: IF THE ANSYS/MAZE GLOBAL COORDINATE SYSTEM IS DIFFERENT
THAN THE MAJOR AND MINOR AXES OF THE LAMINATE YOU WISH TO USE,
YOU MUST EXIT THIS ROUTINE AND USE "LAMINATE" TO DEFINE A NEW
LAYUP WITH THE PROPER ORIENTATION. ALL PREVIOUSLY DEFINED
MATERIALS WILL BE SAVED. FOR EXAMPLE, IF A [0/90] LAMINATE IS
TO BE SITUATED AT A 7 DEGREE ANGLE FROM THE GLOBAL X-AXIS, DEFINE
A [7/97] LAMINATE INSTEAD. QUASI-ISOTROPIC LAMINATES DO NOT NEED
TO BE ORIENTED AT ANY PARTICULAR ANGLE.

TYPE [E] TO USE AN EXISTING LAMINATE; TYPE [D] TO EXIT AND DEFINE
A NEW ONE. TYPE [ENTER] TO LIST CURRENT LAMINATES. **E**

ENTER THE LAMINATE ID CODE: **L11**

TYPE [P] IF DEFINING A 2-DIMENSIONAL PLANE SOLID IN THE
X-Y PLANE; TYPE [A] IF DEFINING AN AXISYMMETRIC SOLID WITH
SYMMETRY AROUND THE Y-AXIS IN THE Z-DIRECTION. **P**

ENTER A HEADING FOR THIS MATERIAL DEFINITION OF EIGHTY OR FEWER
CHARACTERS, OR TYPE [ENTER] TO ACCEPT THE DEFAULT HEADING.
>**LAMINATE [0(2)/45/-45] FROM T300/5208**

ENTER HOURGLASS "Q" (0.0 < Q < 0.1): **0.06**

DATA BLOCK COMPLETE. PRESS ANY KEY TO CONTINUE. [**ENTER**]

FILE GENERATION COMPLETE. PRESS ANY KEY TO CONTINUE. [**ENTER**]

At this point, control returns to the previous menu, which displays the available file types. To view the contents of this file, exit the CDI program and type the following command in the R:BASE command mode.

R>**TYPE MAZE.SPL**

The sample material definitions in this file are also included in Appendix 4 for reference purposes.

7 DATABASE SCHEMA

The Composites Database is stored in three nonreadable binary files named COMP1.RBF, COMP2.RBF, and COMP3.RBF. Of these files, the first contains the database schema, the second contains the database contents, and the third contains the key structure. The database schema is enumerated and described within this section of the manual. To see an actual R:BASE listing of the database tables and columns, including data types, refer to Appendix 6.

- UNICOMP: Contains general information related to the composition and description of a unidirectional composite material.
    - UNID: Unique database identifier of a unidirectional composite
    - UNINAME: Commonly used composite name or identification
    - CLASS: Composite class, typically same as fiber type
    - FIBER: Name of fiber used in the composite
    - MATRIX: Name of matrix used in the composite
    - PRODFORM: Form in which the composite product is available
    - PROCESS: Processing which the composite has undergone

- UNIPROP: Contains material property information of unidirectional composite materials, specifically that which is relevant to finite element analysis.
    - UNID: Unique database identifier of a unidirectional composite
    - EX: Modulus of elasticity in fiber direction, in psi
    - EY: Modulus of elasticity transverse to fiber, in psi
    - ALPX: Coefficient of thermal expansion in fiber direction, unitless quantity
    - ALPY: Coefficient of thermal expansion transverse to fiber, unitless quantity
    - NUYX: Major Poisson's ratio, unitless quantity
    - NUXY: Minor Poisson's ratio, unitless quantity computed from NUYX.
    - GXY: Shear modulus of elasticity, in psi
    - DENS: Composite density, in lbf-s^2/in

- LAMINATE: Contains the necessary information for complete identification of a laminated composite material.
    - LAMID: Unique database identifier of a laminated composite
    - UNID: Unidirectional composite used in the laminate
    - LAMCODE: Laminate code indicating ply orientations and thicknesses

- LAMPROP: Contains stiffness coefficients and material property data about laminated composite materials, including the data necessary to perform finite element analysis.
  - LAMID: Unique database identifier of a laminated composite
  - A11: Coefficient in position (1,1) of normalized laminate stiffness matrix, in psi
  - A12: Coefficient in position (1,2) of normalized laminate stiffness matrix , in psi
  - A16: Coefficient in position (1,6) of normalized laminate stiffness matrix, in psi
  - A22: Coefficient in position (2,2) of normalized laminate stiffness matrix, in psi
  - A26: Coefficient in position (2,6) of normalized laminate stiffness matrix, in psi
  - A66: Coefficient in position (6,6) of normalized laminate stiffness matrix, in psi
  - E1: Major elastic modulus (at zero degrees rotation), in psi
  - E2: Minor elastic modulus (at ninety degrees rotation), in psi
  - G12: Shear modulus of elasticity, in psi
  - NU21: Major Poisson's ratio for the laminate, unitless quantity
  - ALP1: Major coefficient of thermal expansion, unitless quantity
  - ALP2: Minor coefficient of thermal expansion, unitless quantity
  - ALP12: Coefficient of thermal expansion at forty-five degrees, unitless quantity

8 REFERENCES

[1] Microrim, Inc., *R:BASE For DOS*, Version 2.1, Redmond, WA (1988).

[2] Swanson Analysis Systems, Inc., *ANSYS*, Revision 4.4, Houston, PA (1989).

[3] Tsai, S.W., *Composites Design*, Think Composites, Dayton, OH (1987).

[4] MAZE

APPENDIX 1:

DATA ENTRY FORMS

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Appendix 1: Data Entry Forms

Included in this appendix are copies of the data entry forms used in the *Enter Database Data* and *Modify Database Data* options on the *Database Actions* menu of the Composites Database Interface. Each form is identified by the form name and the corresponding table into which its data is placed. Refer to Appendix 6 for a listing of the tables themselves, and to Section 7 for descriptions of both tables and columns.

FORM: ucompfrm
TABLE: unicomp

UNIDIRECTIONAL COMPOSITE MATERIALS

IDENTIFICATION CODE:

COMPOSITE NAME:

TYPE OR CLASS:

FIBER:

MATRIX:

FORM IN WHICH THE
PRODUCT IS AVAILABLE:

PROCESSING WHICH THE
COMPOSITE HAS UNDERGONE:

FORM: upropfrm
TABLE: uniprop

UNIDIRECTIONAL COMPOSITE MATERIALS

IDENTIFICATION CODE: FIBER:
COMPOSITE NAME: MATRIX:
CLASS:

ELASTIC MODULI:
EX: (psi)
EY: (psi)

THERMAL EXPANSION COEF.:
ALPX: (in/in-° C)
ALPY: (in/in-° C)

POISSON'S RATIOS:
NUYX (MAJOR):
NUXY (MINOR):

SHEAR MODULI OF ELASTICITY:
GXY: (psi)

DENSITY: (lbf-s^2/in^4 = lbf/in^3 ÷ 386.4 in/s^2)

FORM: lpropfrm
TABLE: lamprop

LAMINATED COMPOSITE MATERIALS

IDENTIFICATION CODE: COMPOSITE NAME:
LAMINATE CODE:

COEFFICIENTS OF NORMALIZED LAMINATE STIFFNESS MATRIX

A11:	(psi)	A12:	(psi)	A16:	(psi)
A22:	(psi)	A26:	(psi)	A66:	(psi)

ELASTIC MODULI:
E1: (psi)
E2: (psi)

THERMAL EXPANSION COEF.:
ALP1: (in/in-° C)
ALP2: (in/in-° C)

POISSON'S RATIO:
NU21:

SHEAR MODULUS OF ELASTICITY:
G12: (psi)

APPENDIX 2:

SAMPLE REPORTS

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Appendix 2: Sample Reports

Following are examples of the reports that can be obtained by using both the *Views* and *Reports* options of the Composites Database Interface. The report variation chosen for the sample illustration is marked with an asterisk under the *Possibilities* heading.

REPORT: unid
TABLE: unicomp
DESCRIPTION: Identification report of unidirectional composites
POSSIBILITIES: All unidirectionals*, or by class

UNIDIRECTIONAL COMPOSITE MATERIALS

ID CODE	UNI. NAME	CLASS	FIBER	MATRIX
U1	T300/5208	CFRP	T300	N5208
U2	AS/H3501	CFRP	AS	H3501

REPORT: unirpt
TABLE: unicomp
DESCRIPTION: Material property report of unidirectional composites
POSSIBILITIES: All unidirectionals, or by class*

A SUMMARY OF PROPERTIES OF
UNIDIRECTIONAL COMPOSITE MATERIALS

```
ID CODE      NAME            CLASS           FIBER        MATRIX

U1           T300/5208       CFRP            T300         N5208

PRODUCT FORM: Tape or cloth          PROCESSING: Autoclave
EX:    2.63E7 (psi)    ALPX:    2.E-8 (in/in-'C)     NUYX:       0.28
EY: 1490000. (psi)     ALPY:  2.25E-5 (in/in-'C)     NUXY: 0.015863
GXY: 1040000. (psi)                DENSITY:  3.08E-5 (lbf-s^2/in^4)

ID CODE      NAME            CLASS           FIBER        MATRIX

U2           AS/H3501        CFRP            AS           H3501

PRODUCT FORM: Sheets or tape         PROCESSING: Autoclave
EX:      2.E7 (psi)    ALPX: -0-     (in/in-'C)      NUYX:        0.3
EY: 1300000. (psi)     ALPY: -0-     (in/in-'C)      NUXY:    0.0195
GXY: 1030000. (psi)                DENSITY:  3.08E-5 (lbf-s^2/in^4)
```

REPORT: lamid
TABLE: laminate
DESCRIPTION: Identification report of laminated composites
POSSIBILITIES: All laminates, or by composite name*

LAMINATED COMPOSITE MATERIALS

LAM. ID	LAMINATE CODE	UNI. COMPOSITE
L10	QUASI-ISO	T300/5208
L11	[0(2)/45/-45]	T300/5208

REPORT: lamrpt
TABLE: laminate
DESCRIPTION: Material property report of laminated composites
POSSIBILITIES: All laminates, or by composite name*

A SUMMARY OF PROPERTIES OF LAMINATED COMPOSITE MATERIALS

ID CODE	LAMINATE CODE	COMPOSITE NAME
L10	QUASI-ISO	T300/5208

```
E1: 1.0121E7 (psi)    ALP1: 1.126E-5 (in/in-°C)    NU21: 0.296015
E2: 1.0121E7 (psi)    ALP2: 1.126E-5 (in/in-°C)    G12: 3.1E6 (psi)
DENSITY:  3.08E-5 (lbf-s^2/in^4)
```

ID CODE	LAMINATE CODE	COMPOSITE NAME
L11	[0(2)/45/-45]	T300/5208

```
E1: 1.5105E7 (psi)    ALP1:  5.64E-6 (in/in-°C)    NU21: 0.675299
E2: 4239902. (psi)    ALP2: 1.688E-5 (in/in-°C)    G12: 3.9E6 (psi)
DENSITY:  3.08E-5 (lbf-s^2/in^4)
```

APPENDIX 3:

HELP SCREENS

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Appendix 3: Help Screens

Included in this appendix are illustrations of all help screens that are available to the user from the *Help* option of the Composites Database Interface. Each help screen is identified by the CDI Main menu selections necessary to view it.

DATABASE/ENTER DATA

The DATABASE/ENTER DATA option of the Composites Database Interface allows the user to enter new data into the database using on-screen forms. To edit existing data, the user must select the DATABASE/MODIFY DATA option from the main menu instead.

The user must select the database table into which he wishes to enter data. One or more prompts may appear on the screen, followed by data entry forms corresponding to the selected tables, containing numerous prompts. The data entered on the form corresponds to a single row in the table; each prompt corresponds to a particular field of that row.

A highlight cursor will appear beside the first prompt. Data is entered into a field by typing a response to each prompt, followed by a carriage return. Leave a field empty to enter a null value into the database. Move through the data items using either the [Tab] or arrow keys.

Once the data in the form is complete and accurate, press [Esc]; a small menu will appear across the top of the screen. Choose Add or Quit to enter the row into the database, Edit Again to return to the data entry form on the screen, and Discard to clear the form without saving the row. A single row is added to the database with each form; control is either transferred to another applicable form or back to the table selection menu.

DATABASE/MODIFY DATA

The DATABASE/MODIFY DATA option of the Composites Database Interface allows the user to edit or delete existing data in the database using on-screen forms. To enter new data into the database, the user must select the DATABASE/ENTER DATA option from the main menu instead.

The user must select the database table he wishes to edit and perhaps indicate a particular key value. A data editing form corresponding to the selected table will then appear on the screen showing numerous prompts, followed by fields containing data values for the first applicable row in the table.

A small menu will appear across the top of the form. Select Edit to access the first field in the form. To change field values, simply type over the current data value and press return. Move between the fields using either the [Tab] or arrow keys. Press [Esc] to return to the menu.

The remaining menu options function as follows: Save enters the changes to a row into the database, Delete removes the row from the database entirely, and Reset restores the form fields to their original values, losing all changes made during the current edit session. Previous and Next allow the user to page between those rows in the table which meet the specified conditions, while Quit exits the form, saving the data in the current row unless otherwise directed by the user.

DATABASE/ENTER R:BASE DIRECTLY

The DATABASE/ENTER R:BASE option of the Composites Database Interface allows the user to enter the R:BASE Prompt by Example (PBE) mode directly. From the PBE Main Menu, the user can select from among the many R:BASE database operations available in this mode.

Possible PBE actions include modifying data, querying the database using SQL commands, and accessing operating system utilities. Most commonly needed operations can easily be performed using the appropriate PBE options. Certain actions, however, such as modifying the database structure, should be avoided. To return to the Database Actions Menu from Prompt by Example, press [Esc] at the PBE Main Menu.

VIEWS

The VIEWS option of the Composites Database Interface allows the user to view, on the screen, selected data from the database. To print out hard copy reports, the user must select the REPORTS option from the main menu instead.

The user must select a table or category of data to view, and often he must also choose a search or sort category. After the user has responded to each prompt, the appropriate data is displayed on the screen.

If the number of rows to be viewed is more than twenty lines, there will be a pause in the scrolling, allowing the user to examine the data on the screen. The user may then press [Esc] to stop viewing the data, or any other key to see the next screen. Once all of the selected data has been displayed, the user must press any key to return to the most recently displayed menu.

REPORTS

The REPORTS option of the Composites Database Interface allows the user to generate and print hard copy reports of various data in the database. To view the data on screen, the VIEWS option should be selected from the main memory instead.

The user must select a table or category of data to be printed. He also might have to select an item on which to sort or search. The user should ensure that the printer is on-line and has paper before printing is attempted.

Once all of the information is gathered, report generation is begun. Either a copy of the report or a status message will be displayed on the screen during printing. Control is automatically returned to the most recent menu after the report is printed.

LAMINATE

The LAMINATE option of the Composites Database Interface allows the user to define either quasi-isotropic or general laminates from the unidirectional composite data stored in the database.

As input, the user must provide the name of the unidirectional composite and the laminate code for the laminated composite to be generated. A laminate code should have the following structure:

[orient(vol)/orient(vol)...]factor

where "orient" and "vol" are the orientation and volume fraction of each layer in the laminate. Orientations are entered in degrees with counter-clockwise angles positive; volume fraction is a dimensionless quantity. "Factor" is an optional parameter which indicates that the laminate code represents only a portion of the layup, a sublaminate. An "S" indicates that the sublaminate is repeated symmetrically; a digit represents the number of repeating sublaminates in the layup.

Selecting the LAMINATE option places both normalized laminate stiffness properties and on-axis material properties for the new laminate into the database, along with the proper identifying information.

FILES/ANSYS

The FILES/ANSYS option of the Composites Database Interface allows the user to create an ANSYS User file of material data suitable for use with batch input to the ANSYS finite element analysis program.

The User file consists of a separate data block for each material defined within. The *USE command allows ANSYS to access the specially prepared User file. The proper syntax for this command is:

*USE datablock,mat.no.a,mat.no.b,increment

which indicates that "datablock" is the material data block from which to retrieve data on materials "mat.no.a" through "mat.no.b" incremented by "increment."

In addition, the *UFILE command is used in the batch input file

to identify the User file name as follows:
*UFILE filename.extension

The proper use of these two commands in the ANSYS input file is imperative to ensure correct execution and output of the finite element analysis program.

The data items needed to generate a data block for analysis of an axisymmetric solid are EX, EY, EZ, NUXY, NUYZ, NUXZ, ALPX, ALPY, ALPZ, DENS, GXY, GYZ, and GXZ. For a two-dimensional plane solid, fewer properties are required. Other program prompts allow the user to name the User file, change the data block names, and fill in missing data items. After the ANSYS User file has been generated, control is returned to the analysis program selection menu.

FILES/MAZE

The FILES/MAZE option of the Composites Database Interface allows the user to create a material data file suitable for use as an input file to the MAZE preprocessor for the DYNA2D and NIKE2D finite element analysis programs.

The database items necessary to define an axisymmetric solid in the data file are EX(EA), EY(EB), EZ(EC), NUYX(PRBA), NUZY(PRCB), NUZX(PRCA), DENS(RO), and GXY(GAB). Other program prompts allow *the user to name the data file and fill in missing data items.* After the MAZE data file has been generated, control is returned to the analysis program selection menu.

The newly generated file is stored on the currently active directory and drive. It contains only material data and should be merged with an appropriate MAZE input file before analysis is attempted. Each material in the file must be referenced appropriately using the material identification number with which it was defined.

ANALYSIS/ANSYS

The ANALYSIS/ANSYS option of the Composites Database Interface allows the user to run the ANSYS finite element analysis program. Prior to analysis, two steps must occur: 1) an input file containing the finite element mesh and other ANSYS commands must be created on a text editor, and 2) an ANSYS User file containing material property data must be generated using the FILES/ANSYS option. Note that the ANSYS input file must contain the proper usage of the *UFILE and *USE commands to ensure correct access the ANSYS User file. Proper syntax and usage for these commands is explained in the help screen for the FILES/ANSYS option.

To run ANSYS, exit from R:BASE For DOS, transfer all files to the appropriate workstation environment, and initiate the ANSYS program.

ANALYSIS/MAZE

The ANALYSIS/MAZE option of the Composites Database Interface allows the user to run the MAZE preprocessor for the NIKE2D or DYNA2D finite element analysis programs. Prior to analysis, three steps must occur: 1) an input file containing the finite element mesh must be created using a text editor, 2) a file containing material properties and related commands must be generated using the FILES/MAZE option, and 3) the two files must be merged using a text editor or system commands to create a file that can be directly used as an input file to MAZE.

To run MAZE, exit from R:BASE For DOS, transfer all necessary files to the appropriate workstation environment, and initiate MAZE.

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APPENDIX 4:

INPUT FILES FOR FINITE ELEMENT ANALYSIS

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Appendix 4: Input Files for Finite Element Analysis

This appendix contains the material data input files necessary to run both the MAZE preprocessor and the ANSYS finite element analysis program. ANSYS input consists of a User file of material data to be used in conjunction with (but not merged into) a batch input file. The MAZE material data file, on the other hand, is to be merged with the remaining data in the batch input file. Although each User file and material data file can contain one or more material definitions, the code comprising each definition is listed individually under the proper heading. Refer to Section 6 for a discussion of both types of input file.

ANSYS User Files (ANS2_D.SPL, ANS_AXI.SPL)

1) Unidirectional composite aligned in x-direction of plane solid

```
UNI-0
C*** T300/5208 UNIDIRECTIONAL W/ FIBER IN X-DIRECTION (ZERO DEGREES)
C***
C*** The following data block defines material prop-
C*** erties for the above listed composite material.
C***
*SET,AR10,ARG1
*IF,ARG2,GT,0,HERE,2
*SET,ARG2,ARG1
*IF,ARG3,GT,0,HERE,2
*SET ARG3,1
MP,EX,AR10,26300000.
MP,EY,AR10,1490000.
MP,ALPX,AR10,0.000000
MP,ALPY,AR10,0.000022
MP,NUXY,AR10,0.015863
MP,DENS,AR10,0.000030
MP,GXY,AR10,1040000.
*IF,AR10,GE,ARG2,HERE,3
*SET,AR10,AR10+ARG3
*GO,,10
/EOF
```

2) Unidirectional composite at 30 degrees (ccw) from x-direction of plane solid

```
UNI-30
C*** T300/5208 UNIDIRECTIONAL W/ FIBER AT 30 DEGREES CCW FROM X-AXIS
C***
C*** The following data block defines material prop-
C*** erties for the above listed composite material.
C***
*SET,AR10,ARG1
*IF,ARG2,GT,0,HERE,2
*SET,ARG2,ARG1
*IF,ARG3,GT,0,HERE,2
*SET ARG3,1
MP,EX,AR10,4173096.75
MP,EY,AR10,1797949.25
MP,ALPX,AR10,0.000005
MP,ALPY,AR10,0.000016
MP,NUXY,AR10,0.097043
MP,DENS,AR10,0.000030
MP,GXY,AR10,1268670.25
*IF,AR10,GE,ARG2,HERE,3
*SET,AR10,AR10+ARG3
*GO,,10
/EOF
```

3) Laminated composite with [0(2)/45/-45] laminate code, used in a plane solid

```
LAM1
C*** LAMINATE [0(2)/45/-45] FROM T300/5208
C***
C*** The following data block defines material prop-
C*** erties for the above listed composite material.
C***
*SET,AR10,ARG1
*IF,ARG2,GT,0,HERE,2
*SET,ARG2,ARG1
*IF,ARG3,GT,0,HERE,2
*SET ARG3,1
MP,EX,AR10,15105000.
MP,EY,AR10,4239902.
MP,ALPX,AR10,0.000005
MP,ALPY,AR10,0.000016
MP,NUXY,AR10,0.189553
MP,DENS,AR10,0.000030
MP,GXY,AR10,3904441.
*IF,AR10,GE,ARG2,HERE,3
*SET,AR10,AR10+ARG3
*GO,,10
/EOF
```

4) Unidirectional composite hoop-wound at 30 degrees from z-direction (hoop)

```
HW.U-30
C*** T300/5208 UNI. HOOP-WOUND W/ FIBER AT 30 DEGREES CCW FROM Z-AXIS
C***
C*** The following data block defines material prop-
C*** erties for the above listed composite material.
C***
*SET,AR10,ARG1
*IF,ARG2,GT,0,HERE,2
*SET,ARG2,ARG1
*IF,ARG3,GT,0,HERE,2
*SET ARG3,1
MP,EX,AR10,1490000.
MP,EY,AR10,1797949.25
MP,EZ,AR10,4173097.
MP,ALPX,AR10,0.000022
MP,ALPY,AR10,0.000016
MP,ALPZ,AR10,0.000005
MP,NUXY,AR10,***
MP,NUYZ,AR10,0.225240
MP,NUXZ,AR10,***
MP,DENS,AR10,0.000030
MP,GXY,AR10,***
*IF,AR10,GE,ARG2,HERE,3
*SET,AR10,AR10+ARG3
*GO,,10
/EOF
```

MAZE Material Data File (MAZE.SPL)

1) Unidirectional composite aligned in x-direction of plane solid

```
MAT 1 2 HEAD
T300/5208 UNIDIRECTIONAL W/ FIBER IN X-DIRECTION (ZERO DEGREES)
EA 26300000.
EB 1490000.
EC 1490000.
PRBA 0.280000
PRCB ***
PRCA ***
RO 0.000030
GAB 1040000.
AOPT 2.0
RP
ZP
PSIG 0.0
HGQ 0.059999
ENDMAT
```

2) Unidirectional composite at 30 degrees (ccw) from x-direction of plane solid

```
MAT 2 2 HEAD
T300/5208 UNIDIRECTIONAL W/ FIBER AT 30 DEGREES CCW FROM X-AXIS
EA 4173096.75
EB 1797949.25
EC 1490000.
PRBA 0.225239
PRCB ***
PRCA ***
RO 0.000030
GAB 1268670.25
AOPT 2.0
RP
ZP
PSIG 0.0
HGQ 0.059999
ENDMAT
```

3) Laminated composite with [0(2)/45/-45] laminate code, used in a plane solid

```
MAT 3 2 HEAD
T300/5208 UNI. HOOP-WOUND W/ FIBER AT 30 DEGREES CCW FROM Z-AXIS
EA 1490000.
EB 1797949.25
EC 4173097.
PRBA ***
PRCB 0.097043
PRCA ***
RO 0.000030
GAB ***
AOPT 2.0
RP
ZP
PSIG 0.0
HGQ 0.059999
ENDMAT
```

4) Unidirectional composite hoop-wound at 30 degrees from z-direction (hoop)

```
MAT 4 2 HEAD
LAMINATE [0(2)/45/-45] FROM T300/5208
EA 15105000.
EB 4239902.
EC 1490000.
PRBA 0.675298
PRCB ***
PRCA ***
RO 0.000030
GAB 3904441.
AOPT 2.0
RP
ZP
PSIG 0.0
HGQ 0.059999
ENDMAT
```

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APPENDIX 5:

APPLICATION PROGRAM LISTINGS

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Appendix 5: Application Program Listings

Following are the actual program listings for all programs in the Composites Database Interface. The first few lines of each program contain the program name and a brief description of its purpose. Note that MENUS.PRO, which contains the program screens and menus, is a binary file; the ASCII equivalent, MENUS.APP is listed instead.

COMP.CMD

```
*(COMP.CMD:  Composites database interface.  Allows a user to access a
composites materials database, enter and edit data, view and generate
reports of this data, create interface files suitable for use with
various finite element analysis programs, and run these analysis
programs.)

*(Set program environment, open database and display introductory
screen.)
SET MESSAGES OFF
SET ERROR MESSAGE OFF
CLS
SET COLOR BACKGRND blue
SET COLOR FOREGRND light cyan
SET BELL OFF
CLEAR ALL VAR
SET VAR PICK1 TEXT
OPEN COMP
DISPLAY intro IN menus.pro
PAUSE
LABEL startapp
NEWPAGE

*(Display main menu of all possible categories and acquire user's
selection.)
CHOOSE PICK1 FROM MAIN IN menus.pro

*(User selects help screens.  Run HELP.CMD to provide help screens to
the user.)
IF PICK1 EQ "HELP " THEN
  RUN help.cmd
  GOTO startapp
ENDIF

*(User selects database actions.  Run DATA.CMD, a subroutine which
allows user to enter or edit database data, and access R:BASE
directly.)
IF PICK1 EQ "DATABASE" THEN
  RUN data.cmd
  GOTO startapp
ENDIF

*(User elects to view data on screen.  Run VIEW_RPT.CMD program,
allowing him to choose data and search categories.)
IF PICK1 EQ "VIEWS " THEN
  RUN view_rpt.cmd
```

```
  GOTO startapp
ENDIF

*(User elects to print paper reports.  Also run VIEW_RPT.CMD program,
except that selected data is now sent to the printer rather than to
the screen.)
IF PICK1 EQ "REPORTS " THEN
  RUN view_rpt.cmd
  GOTO startapp
ENDIF

*(User elects to design laminates using existing unidirectional com-
posite data.  Run LAM.CMD, which generates and stores laminate data.)
IF PICK1 EQ "LAMINATE" THEN
   RUN lam.cmd
   GOTO startapp
ENDIF

*(User selects interface files.  Run FIlES.CMD, which will create a
file of material property data suuitable for use with an analysis
code.)
IF PICK1 EQ "FILES " THEN
  RUN files.cmd
  GOTO startapp
ENDIF

*(User selects analysis programs.  ...)

IF PICK1 EQ "ANALYSIS " THEN
  GOTO startapp
ENDIF

*(User elects to exit the program.  Reset the environment and return
control to the keyboard.)
IF PICK1 EQ "EXIT      " THEN
  GOTO endapp
ENDIF
GOTO startapp
LABEL endapp
CLS
SET MESSAGES ON
SET ERROR MESSAGES ON
SET BELL ON
CLEAR ALL VAR
CLEAR PICK1
INPUT KEYBOARD
```

MENUS.APP

```
$SCREEN
INTRO
```

```
èëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë£
¤                                                  ¤
¤               WELCOME TO THE CDI                 ¤
¤                                                  ¤
¤                     *****                        ¤
¤                                                  ¤
¤        COMPOSITES  DATABASE  INTERFACE           ¤
¤                                                  ¤
¤                     *****                        ¤
¤                                                  ¤
¤            PRESS ANY KEY TO CONTINUE             ¤
¤                                                  ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëÎ

$SCREEN
MAINSCR
èëëëëëëëëëëëëëëëëëëë*** CDI  MAIN  MENU  (Make a selection)
***ëëëëëëëëëëëëëëëëëëë£
¤  HELP      DATABASE  VIEWS     REPORTS   LAMINATE  FILES
ANALYSIS       ¤
¤  EXIT
¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë
ëëëëëëëëÎ
$SCREEN
HELPSCR
èëëëëëëëëë*** HELP MENU  (Select a topic for help menus or screens)
***ëëëëëëëë£
¤  DATABASE  VIEWS     REPORTS   LAMINATE  FILES     ANALYSIS  EXIT
¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë
ëëëëëëëëÎ
$SCREEN
FILESCR
èëëëë*** GENERATE INTERFACE FILES  (Select applicable analysis
program) ***ëëë£
¤  ANSYS   MAZE    INGRID  Exit
¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë
ëëëëëëëëÎ
$SCREEN
DBASESCR
èëëëëëëëëëëëëëëëëëë*** DATABASE ACTIONS  (Select an action)
***ëëëëëëëëëëëëëëëëëëë£
¤                          (1)  Enter database data
¤
¤                          (2)  Modify database data
¤
¤                          (3)  Enter R:BASE directly
¤
¤                          (4)  Exit to previous menu
¤
```

```
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë
ëëëëëëëëî
$SCREEN
VIEWSCR
èëëëëëëëëëëëë*** VIEW DATA ON SCREEN  (Select a data category)
***ëëëëëëëëëëëë£
¤                        (1)  Unidirectional composites
¤
¤                        (2)  Laminated composites
¤
¤                        (3)  Exit to previous menu
¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë
ëëëëëëëëî
$SCREEN
REPTSCR
èëëëëëëëëëëëë*** PRINT DATABASE REPORTS  (Select a report type)
***ëëëëëëëëëëëë£
¤                        (1)  Unidirectional composites
¤
¤                        (2)  Laminated composites
¤
¤                        (3)  Exit to previous menu
¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë
ëëëëëëëëî
$SCREEN
VTYPSCR
èëëëëëëëëëëëë*** TYPE OF REPORT/VIEW  (Select a data category)
***ëëëëëëëëëëëë£
¤            (1)  Identification report (ID no., class, fiber, etc.)
¤
¤            (2)  Material property report (ID no., EX, EY, etc.)
¤
¤            (3)  Exit to previous menu
¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë
ëëëëëëëëî
$SCREEN
ENTERTYP
èëëëëëëëëëëëë*** ENTER DATABASE DATA  (Select a data category)
***ëëëëëëëëëëëë£
¤                        (1)  Unidirectional composites
¤
¤                        (2)  Laminated composites
¤
¤                        (3)  Exit to previous menu
¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë
ëëëëëëëëî
$SCREEN
EDITTYP
èëëëëëëëëëëë*** MODIFY DATABASE DATA  (Select a data category)
***ëëëëëëëëëëëë£
```

```
¤                              (1)  Unidirectional composites
¤
¤                              (2)  Laminated composites
¤
¤                              (3)  Exit to previous menu
¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë
ëëëëëëëëî
$MENU
MAIN
ROW *** CDI  MAIN  MENU  (Make a selection) ***
HELP
DATABASE
VIEWS
REPORTS
LAMINATE
FILES
ANALYSIS
EXIT
$MENU
HELP
ROW *** HELP MENU  (Select a topic for help menus or screens) ***
DATABASE
VIEWS
REPORTS
LAMINATE
FILES
ANALYSIS
EXIT
$MENU
DATABASE
COLUMN *** DATABASE ACTIONS  (Select an action) ***
Enter database data
Modify database data
Enter R:BASE directly
Exit to previous menu
$MENU
ENTER
COLUMN *** ENTER DATABASE DATA  (Select a data category) ***
Unidirectional composites
Laminated composites
Exit to previous menu
$MENU
EDIT
COLUMN *** MODIFY DATABASE DATA  (Select a data category) ***
Unidirectional composites
Laminated composites
Exit to previous menu
$MENU
REPORT
COLUMN *** PRINT DATABASE REPORTS  (Select a report type) ***
Unidirectional composites
Laminated composites
Exit to previous menu
```

```
$MENU
VIEWS
COLUMN *** VIEW DATA ON SCREEN  (Select a data category) ***
Unidirectional composites
Laminated composites
Exit to previous menu
$MENU
VIEWTYP
COLUMN *** TYPE OF REPORT/VIEW  (Select a data category) ***
Identification report (ID no., class, fiber, etc.)
Material property report (ID no., EX, EY, etc.)
Exit to previous menu
$MENU
UNIVIEW
COLUMN *** SEARCH CATEGORIES  (Select appropriate category) ***
View by class
View all composites
Exit to previous menu
$MENU
LAMVIEW
COLUMN *** SEARCH CATEGORIES  (Select appropriate category) ***
View by composite name
View all laminates
Exit to previous menu
$MENU
FILES
ROW *** GENERATE INTERFACE FILES  (Select applicable analysis program)
***
ANSYS
MAZE
EXIT
$MENU
HDATA
ROW *** HELP FOR DATABASE ACTIONS  (Select a topic for help screens)
***
ENTRY
EDITING
R:BASE
EXIT
$MENU
HFILES
ROW *** HELP FOR INTERFACE FILES  (Select a topic for help screens)
***
ANSYS
MAZE
EXIT
$MENU
HANAL
ROW *** HELP FOR ANALYSIS PROGRAMS  (Select a topic for help screens)
***
ANSYS
MAZE
EXIT
$SCREEN
```

HENTRY

The DATABASE/ENTER DATA option of the Composites Database Interface allows the user to enter new data into the database using on-screen forms. To edit existing data, the user must select the DATABASE/MODIFY DATA option from the main menu instead.

The user must select the database table into which he wishes to enter data. One or more prompts may appear on the screen, followed by data entry forms corresponding to the selected tables, containing numerous prompts. The data entered on the form corresponds to a single row in the table; each prompt corresponds to a particular field of that row.

A highlight cursor will appear beside the first prompt. Data is entered into a field by typing a response to each prompt, followed by a carriage return. Leave a field empty to enter a null value into the database. Move through the data items using either the [Tab] or arrow keys.

Once the data in the form is complete and accurate, press [Esc]; a small menu will appear across the top of the screen. Choose Add or Quit to enter the row into the database, Edit Again to return to the data entry form on the screen, and Discard to clear the form without saving the row. A single row is added to the database with each form; control is either transferred to another applicable form or back to the table selection menu.

$SCREEN
HEDIT

The DATABASE/MODIFY DATA option of the Composites Database Interface allows the user to edit or delete existing data in the database using on-screen forms. To enter new data into the database, the user must select the DATABASE/ENTER DATA option from the main menu instead.

The user must select the database table he wishes to edit and perhaps indicate a particular key value. A data editing form corresponding to the selected table will then appear on the screen showing numerous prompts, followed by fields containing data values for the first applicable row in the table.

A small menu will appear across the top of the form. Select Edit to access the first field in the form. To change field values, simply type over the current data value and press return. Move between the fields using either the [Tab] or arrow keys. Press [Esc] to return to the menu.

The remaining menu options function as follows: Save enters the changes to a row into the database, Delete removes the row from the database entirely, and Reset restores the form fields to their original values, losing all changes made during the current edit session. Previous and Next allow the user to page between those rows in the table which meet the specified conditions, while Quit exits the form, saving the data in the current row unless otherwise directed by the user.

$SCREEN
HRBASE

The DATABASE/ENTER R:BASE option of the Composites Database Interface allows the user to enter the R:BASE Prompt by Example (PBE) mode directly. From the PBE Main Menu, the user can select from among the many R:BASE database operations available in this mode.

Possible PBE actions include modifying data, querying the database using SQL commands, and accessing operating system utilities. Most commonly needed operations can easily be performed using the appropriate PBE options. Certain actions, however, such as modifying the database structure, should be avoided. To return to the Database Actions Menu from Prompt by Example, press [Esc] at the PBE Main Menu.

$SCREEN
HVIEWS

The VIEWS option of the Composites Database Interface allows the user to view, on the screen, selected data from the database. To print out hard copy reports, the user must select the REPORTS option from the main menu instead.

The user must select a table or category of data to view, and often he must also choose a search or sort category. After the user has responded to each prompt, the appropriate data is displayed on the screen.

If the number of rows to be viewed is more than twenty lines, there will be a pause in the scrolling, allowing the user to examine the data on the screen. The user may then press [Esc] to stop viewing the data, or any other key to see the next screen. Once all of the selected data has been displayed, the user must press any key to return to the most recently displayed menu.

$SCREEN
HREPORTS

The REPORTS option of the Composites Database Interface allows the user to generate and print hard copy reports of various data in the database. To view the data on screen, the VIEWS option should be selected from the main memory instead.

The user must select a table or category of data to be printed. He also might have to select an item on which to sort or search. The user should ensure that the printer is on-line and has paper before printing is attempted.

Once all of the information is gathered, report generation is begun. Either a copy of the report or a status message will be displayed on the screen during printing. Control is automatically returned to the most recent menu after the report is printed.

$SCREEN
HLAM

The LAMINATE option of the Composites Database Interface allows the user to define either quasi-isotropic or general laminates from the unidirectional composite data stored in the database.

As input, the user must provide the name of the unidirectional composite and the laminate code for the laminated composite to be generated. A laminate code should have the following structure:

[orient(vol)/orient(vol)...]factor

where "orient" and "vol" are the orientation and volume fraction of each layer in the laminate. Orientations are entered in degrees with counter-clockwise angles positive; volume fraction is a dimensionless quantity. "Factor" is an optional parameter which indicates that the laminate code represents only a portion of the layup, a sublaminate. An "S" indicates that the sublaminate is repeated symmetrically; a digit represents the number of repeating sublaminates in the layup.

Selecting the LAMINATE option places both normalized laminate stiffness properties and on-axis material properties for the new laminate into the database, along with the proper identifying information.

$SCREEN
HANSYS

The FILES/ANSYS option of the Composites Database Interface allows the user to create an ANSYS User file of material data suitable for use with batch input to the ANSYS finite element analysis program.

The User file consists of a separate data block for each material defined within. The *USE command allows ANSYS to access the specially prepared User file. The proper syntax for this command is:

*USE datablock,mat.no.a,mat.no.b,increment

which indicates that "datablock" is the material data block from which to retrieve data on materials "mat.no.a" through "mat.no.b" incremented by "increment."

In addition, the *UFILE command is used in the batch input file to identify the User file name as follows:

```
*UFILE filename,extension
```

The proper use of these two commands in the ANSYS input file is imperative to ensure correct execution and output of the finite element analysis program.

The data items needed to generate a data block for analysis of an axisymmetric solid are EX, EY, EZ, NUXY, NUYZ, NUXZ, ALPX, ALPY, ALPZ, DENS, GXY, GYZ, and GXZ. For a two-dimensional plane solid, fewer properties are required. Other program prompts allow the user to name the User file, change the data block names, and fill in missing data items. After the ANSYS User file has been generated, control is returned to the analysis program selection menu.

$SCREEN
HMAZE

The FILES/MAZE option of the Composites Database Interface allows the user to create a material data file suitable for use as an input file to the MAZE preprocessor for the DYNA2D and NIKE2D finite element analysis programs.

The database items necessary to define an axisymmetric solid in the data file are EX(EA), EY(EB), EZ(EC), NUYX(PRBA), NUZY(PRCB), NUZX(PRCA), DENS(RO), and GXY(GAB). Other program prompts allow the user to name the data file and fill in missing data items. After the MAZE data file has been generated, control is returned to the analysis program selection menu.

The newly generated file is stored on the currently active directory and drive. It contains only material data and should be merged with an appropriate MAZE input file before analysis is attempted. Each material in the file must be referenced appropriately using the material identification number with which it was defined.

$SCREEN
HANANSYS

The ANALYSIS/ANSYS option of the Composites Database Interface allows the user to run the ANSYS finite element analysis program. Prior to analysis, two steps must occur: 1) an input file containing the finite element mesh and other ANSYS commands must be created on a text editor, and 2) an ANSYS User file containing material property data must be generated using the FILES/ANSYS option. Note that the ANSYS input file must contain the proper usage of the *UFILE and *USE commands to ensure correct access the ANSYS User file. Proper syntax and usage for these commands is explained in the help screen for the FILES/ANSYS option.

To run ANSYS, exit from R:BASE For DOS, transfer all files to the appropiate workstation environment, and initiate the ANSYS program.

$SCREEN
HANMAZE

The ANALYSIS/MAZE option of the Composites Database Interface allows the user to run the MAZE preprocessor for the NIKE2D or DYNA2D finite element analysis programs. Prior to analysis, three steps must occur: 1) an input file containing the finite element mesh must be created using a text editor, 2) a file containing material properties and related commands must be generated using the FILES/MAZE option, and 3) the two files must be merged using a text editor or system commands to create a file that can be directly used as an input file to MAZE.

To run MAZE, exit from R:BASE For DOS, transfer all necessary files to the appropriate workstation environmnent, and initiate MAZE.

HELP.CMD

```
*(HELP.CMD:  This subroutine is run from the main program if the user
elect to view help screens.  It presents a second menu listing menu
options for which help is available.  The user selects a category, and
the appropriate help screnn is presented.)

SET VAR PICK2 TEXT
SET VAR LEVEL2 INT
SET VAR LEVEL2 TO 0
WHILE LEVEL2 EQ 0 THEN
  CHOOSE PICK2 FROM HELP IN menus.pro AT 5
  IF PICK2 EQ "Esc " THEN
    BREAK
  ENDIF

*(Display help screens appropriate to user's selection.  For database,
files, and analysis help, a further menu is displayed.)
  IF PICK2 EQ "DATABASE " THEN
    SET VAR PICK3 TEXT
    SET VAR LEVEL3 INT
    SET VAR LEVEL3 TO 0
    WHILE LEVEL3 EQ 0 THEN
      CHOOSE PICK3 FROM HDATA IN menus.pro AT 8
      IF PICK3 EQ "Esc " THEN
        CLS FROM 5
        BREAK
```

```
    ENDIF
    IF PICK3 EQ "ENTRY " THEN
      CLS
      DISPLAY hentry IN menus.pro
    ENDIF
    IF PICK3 EQ "EDITING " THEN
      CLS
      DISPLAY hedit IN menus.pro
    ENDIF
    IF PICK3 EQ "R:BASE " THEN
      CLS
      DISPLAY hrbase IN menus.pro
    ENDIF
    IF PICK3 EQ "EXIT " THEN
      CLS FROM 5
      BREAK
    ENDIF
    WRITE " "
    WRITE " PRESS ANY KEY TO CONTINUE "
    PAUSE
    CLS
    DISPLAY mainscr IN menus.pro
    WRITE "HELP " AT 2 4 GRAY
    DISPLAY helpscr IN menus.pro
    WRITE "DATABASE " AT 6 4 GRAY
  ENDWHILE
  CLEAR LEVEL3 PICK3
ENDIF
IF PICK2 EQ "VIEWS " THEN
  CLS
  DISPLAY hviews IN menus.pro
  WRITE " "
  WRITE " PRESS ANY KEY TO CONTINUE "
  PAUSE
  CLS
  DISPLAY mainscr IN menus.pro
  WRITE "HELP " AT 2 4 GRAY
ENDIF
IF PICK2 EQ "REPORTS " THEN
  CLS
  DISPLAY hreports IN menus.pro
  WRITE " "
  WRITE " PRESS ANY KEY TO CONTINUE "
  PAUSE
  CLS
  DISPLAY mainscr IN menus.pro
  WRITE "HELP " AT 2 4 GRAY
ENDIF
IF PICK2 EQ "LAMINATE " THEN
  CLS
  DISPLAY hlam IN menus.pro
  WRITE " "
  WRITE " PRESS ANY KEY TO CONTINUE "
  PAUSE
```

```
    CLS
    DISPLAY mainscr IN menus.pro
    WRITE "HELP " AT 2 4 GRAY
  ENDIF
  IF PICK2 EQ "FILES " THEN
    SET VAR PICK3 TEXT
    SET VAR LEVEL3 INTEGER
    SET VAR LEVEL3 TO 0
    WHILE LEVEL3 EQ 0 THEN
      CHOOSE PICK3 FROM HFILES IN menus.pro AT 8
      IF PICK3 EQ "Esc " THEN
        CLS FROM 5
        BREAK
      ENDIF
      IF PICK3 EQ "ANSYS " THEN
        CLS
        DISPLAY hansys IN menus.pro
      ENDIF
      IF PICK3 EQ "MAZE " THEN
        CLS
        DISPLAY hmaze IN menus.pro
      ENDIF
      IF PICK3 EQ "EXIT " THEN
        CLS FROM 5
        BREAK
      ENDIF
      WRITE " "
      WRITE " PRESS ANY KEY TO CONTINUE "
      PAUSE
      CLS
      DISPLAY mainscr IN menus.pro
      WRITE "HELP " AT 2 4 GRAY
      DISPLAY helpscr IN menus.pro
      WRITE "FILES " AT 6 44 GRAY
    ENDWHILE
    CLEAR LEVEL3 PICK3
  ENDIF
  IF PICK2 EQ "ANALYSIS " THEN
    SET VAR PICK3 TEXT
    SET VAR LEVEL3 INTEGER
    SET VAR LEVEL3 TO 0
    WHILE LEVEL3 EQ 0 THEN
      CHOOSE PICK3 FROM HANAL IN menus.pro AT 8
      IF PICK3 EQ "Esc " THEN
        CLS FROM 5
        BREAK
      ENDIF
      IF PICK3 EQ "ANSYS " THEN
        CLS
        DISPLAY hanansys IN menus.pro
      ENDIF
      IF PICK3 EQ "MAZE " THEN
        CLS
        DISPLAY hanmaze IN menus.pro
```

```
      ENDIF
      IF PICK3 EQ "EXIT " THEN
        CLS FROM 5
        BREAK
      ENDIF
      WRITE " "
      WRITE " PRESS ANY KEY TO CONTINUE "
      PAUSE
      CLS
      DISPLAY mainscr IN menus.pro
      WRITE "HELP " AT 2 4 GRAY
      DISPLAY helpscr IN menus.pro
      WRITE "ANALYSIS " AT 6 54 GRAY
    ENDWHILE
    CLEAR LEVEL3 PICK3
  ENDIF
  IF PICK2 EQ "EXIT " THEN
    BREAK
  ENDIF
ENDWHILE
CLEAR LEVEL2 PICK2
```

DATA.CMD

```
*(DATA.CMD:  Subroutine accessed by COMP.CMD.  Allows user to enter
and edit database data using data entry forms.  Also allows user to
enter R:BASE commands directly through access to R:BASE Prompt by
Example mode.)

*(User has selected database actions from main menu.  Set up a second
menu screen displaying possible actions as described previously.)
SET VAR PICK2 INT
SET VAR LEVEL2 INT
SET VAR LEVEL2 TO 0
SET VAR vct INTEGER
SET VAR vunid TEXT
SET VAR vlamid TEXT
SET VAR vname TEXT
SET VAR vcode TEXT
SET VAR vnext TEXT
WHILE LEVEL2 EQ 0 THEN
  CLS FROM 5
  CHOOSE PICK2 FROM DATABASE IN menus.pro AT 5
  IF PICK2 EQ 0 THEN
    BREAK
  ENDIF

*(User elects to enter data.  Display a third menu illustrating the
various data categories available.)
  IF PICK2 EQ 1 THEN
    SET VAR PICK3 INT
    SET VAR LEVEL3 INT
    SET VAR LEVEL3 TO 0
```

```
    WHILE LEVEL3 EQ 0 THEN
      CHOOSE PICK3 FROM ENTER IN menus.pro AT 11
      IF PICK3 EQ 0 THEN
        BREAK
      ENDIF

*(User elects to enter unidirectional composites data.  Prompt user
for name of composite to be entered and check to see if that material
has already been entered into the database.  If so, allow user to edit
this data.  Otherwise, display entry forms so that user may enter
data.  Continue until user requests to stop.)
      IF PICK3 EQ 1 THEN
        FILLIN vname USING "ENTER THE COMPOSITE'S NAME:  " AT 16 10
        WHILE vname EXISTS THEN
          SET POINTER #1 err1 FOR unicomp WHERE uniname EQ .vname
          IF err1 EQ 0 THEN
            WRITE "THIS MATERIAL HAS ALREADY BEEN ENTERED INTO THE
DATABASE." +
              AT 18 10
            FILLIN vnext=0 USING +
              "TYPE [E] TO EDIT THE DATA, [N] TO ENTER NEW DATA OR
QUIT. " +
              AT 19 10
            IF vnext EQ E THEN
              EDIT USING ucompfrm WHERE uniname EQ .vname
              EDIT USING upropfrm WHERE uniname EQ .vname
            ELSE
              GOTO unient
            ENDIF
          ELSE
            CLS FROM 18
            WRITE "ENTER AN IDENTIFICATION CODE IN THIS FORM: U1, U2."
AT 18 10
            FIL vunid USI "(TYPE [ENTER] TO LIST CURRENTLY USED ID
CODES):  " +
              AT 19 10
            SET VAR vunid TO (ICAP1(.vunid))
            SET VAR err2 TO 0
            WHILE vunid FAILS OR err2 EQ 0 THEN
              IF vunid FAILS THEN
                CLS
                PRINT unid
                WRITE " "
                SET VAR vct TO COUNT unid IN unicomp
                IF vct GT 20 THEN
                  FILLIN vunid USING +
            "          ENTER AN ID CODE OR TYPE [ENTER] TO LIST THOSE
IN USE:  "
                ELSE
                  FILLIN vunid USING "          ENTER AN
IDENTIFICATION CODE:  "
                ENDIF
              ELSE
                SET POINTER #2 err2 FOR unicomp WHERE unid EQ .vunid
```

```
                IF err2 EQ 0 THEN
                  WRITE " "
                 WRI "          THIS IDENTIFICATION CODE IS ALREADY
BEING USED."
                  FILLIN vunid USING +
          "         ENTER ANOTHER ID CODE; TYPE [ENTER] TO LIST THOSE
IN USE:  "
                ENDIF
              ENDIF
              SET VAR vunid TO (ICAP1(.vunid))
            ENDWHILE
            ENTER USING ucompfrm FOR 1 ROW
            ENTER USING upropfrm FOR 1 ROW
          ENDIF
          DISPLAY mainscr IN menus.pro
          WRITE "DATABASE" AT 2 14 GRAY
          DISPLAY dbasescr IN menus.pro
          WRITE "(1)" AT 6 27 GRAY
          DISPLAY entertyp IN menus.pro
          WRITE "(1)" AT 12 25 GRAY
LABEL unient
          CLS FROM 16
          FILLIN vname USING +
             "NAME OF NEXT COMPOSITE TO ENTER (TYPE [ENTER] TO QUIT):
"+
            AT 16 10
        ENDWHILE
        CLS FROM 16
      ENDIF

*(User elects to enter laminated composites data.  Prompt user for the
composite's name and laminate code and check to see if that material
has already been entered into the database.  If so, allow user to edit
this data.  Otherwise, display entry forms so that user may enter
data.  Continue until user requests to stop.)
      IF PICK3 EQ 2 THEN
        FIL vname USI "ENTER THE (UNIDIRECTIONAL) COMPOSITE'S NAME:  "
AT 16 10
        WHILE vname EXISTS THEN
          SET VAR vunid TO unid IN unicomp WHERE uniname EQ .vname
          FIL vcode USI "ENTER THE LAMINATE CODE FOR THE COMPOSITE:  "
AT 17 10
          SET POINTER #1 err1 FOR laminate WHERE lamcode EQ .vcode AND
+
            unid EQ .vunid
          IF err1 EQ 0 THEN
            WRITE "THIS MATERIAL HAS ALREADY BEEN ENTERED INTO THE
DATABASE." +
              AT 19 10
            FILLIN vnext=0 USING +
              "TYPE [E] TO EDIT THE DATA, [N] TO ENTER NEW DATA OR
QUIT. " +
              AT 20 10
            IF vnext EQ E THEN
```

```
              SET VAR vlamid TO lamid IN laminate WHERE lamcode EQ
.vcode AND +
                unid EQ .vunid
              EDIT USING lpropfrm WHERE lamid EQ .vlamid
            ELSE
              GOTO lament
            ENDIF
          ELSE
            CLS FROM 18
            WRITE "ENTER AN IDENTIFICATION CODE IN THIS FORM: L1, L2."
AT 19 10
            FIL vlamid USI "(TYPE [ENTER] TO LIST CURRENTLY USED ID
CODES):  " +
              AT 20 10
            SET VAR vlamid TO (ICAP1(.vlamid))
            SET VAR err2 TO 0
            WHILE vlamid FAILS OR err2 EQ 0 THEN
              IF vlamid FAILS THEN
                CLS
                PRINT lamid
                WRITE " "
                SET VAR vct TO COUNT lamid IN laminate
                IF vct GT 20 THEN
                  FILLIN vlamid USING +
            "          ENTER AN ID CODE OR TYPE [ENTER] TO LIST THOSE
IN USE:  "
                ELSE
                  FIL vlamid USI "          ENTER AN IDENTIFICATION
CODE:  "
                ENDIF
              ELSE
                SET POINTER #2 err2 FOR laminate WHERE lamid EQ
.vlamid
                IF err2 EQ 0 THEN
                  WRITE " "
                  WRITE +
                     "          THIS IDENTIFICATION CODE IS ALREADY
BEING USED."
                  FILLIN vlamid USING +
          "        ENTER ANOTHER ID CODE; TYPE [ENTER] TO LIST THOSE
IN USE:  "
                ENDIF
              ENDIF
              SET VAR vlamid TO (ICAP1(.vlamid))
            ENDWHILE
            LOAD laminate
            .vlamid .vunid .vcode
            END
            ENTER USING lpropfrm FOR 1 ROW
          ENDIF
          DISPLAY mainscr IN menus.pro
          WRITE "DATABASE" AT 2 14 GRAY
          DISPLAY dbasescr IN menus.pro
          WRITE "(1)" AT 6 27 GRAY
```

```
            DISPLAY entertyp IN menus.pro
            WRITE "(2)" AT 13 25 GRAY
LABEL lament
            CLS FROM 16
            FILLIN vname USING +
               "COMPOSITE NAME OF NEXT LAMINATE (TYPE [ENTER] TO QUIT):
" +
              AT 16 10
          ENDWHILE
          CLS FROM 16
        ENDIF
        IF PICK3 EQ 3 THEN
          BREAK
        ENDIF
      ENDWHILE
      CLEAR LEVEL3 PICK3
    ENDIF

*(User elects to edit data.  Display a second menu illustrating the
data categories available.)
    IF PICK2 EQ 2 THEN
      SET VAR PICK3 INT
      SET VAR LEVEL3 INT
      SET VAR LEVEL3 TO 0
      WHILE LEVEL3 EQ 0 THEN
        CHOOSE PICK3 FROM EDIT IN menus.pro AT 11
        IF PICK3 EQ 0 THEN
          BREAK
        ENDIF

*(User elects to edit unidirectional composites data.  Prompt the user
to enter the name of the composite he wishes to edit and check to see
if it is in the database.  If not, allow him to enter it; otherwise,
display the data in an edit form.  Repeat this sequence until the user
elects to stop.)
        IF PICK3 EQ 1 THEN
          CLS FROM 16
          FILLIN vname USING "ENTER A COMPOSITE NAME:  " AT 16 10
          WHILE vname EXISTS THEN
            SET POINTER #1 errl FOR unicomp WHERE uniname EQ .vname
            IF errl NE 0 THEN
              WRITE "THIS MATERIAL HAS NOT YET BEEN ENTERED INTO THE
DATABASE."+
                AT 18 10
              FILLIN vnext=0 USING +
                "TYPE [E] TO ENTER THIS ROW, [C] TO EDIT ANOTHER ROW OR
QUIT."+
                AT 19 10
              IF vnext EQ E THEN
                CLS FROM 18
                WRI "ENTER AN IDENTIFICATION CODE IN THIS FORM: U1, U2."
AT 18 10
                FIL vunid USI "(TYPE [ENTER] TO LIST CURRENTLY USED ID
CODES):  "+
```

```
              AT 19 10
            SET VAR vunid TO (ICAP1(.vunid))
            SET VAR err2 TO 0
            WHILE vunid FAILS OR err2 EQ 0 THEN
              IF vunid FAILS THEN
                CLS
                PRINT unid
                WRITE " "
                SET VAR vct TO COUNT unid IN unicomp
                IF vct GT 20 THEN
                  FILLIN vunid USING +
          "          ENTER AN ID CODE OR TYPE [ENTER] TO LIST THOSE
IN USE:  "
                ELSE
                  FIL vunid USI "          ENTER AN IDENTIFICATION
CODE:  "
                ENDIF
              ELSE
                SET POINTER #2 err2 FOR unicomp WHERE unid EQ .vunid
                IF err2 EQ 0 THEN
                  WRITE " "
                  WRITE +
                   "          THIS IDENTIFICATION CODE IS ALREADY
BEING USED."
                  FILLIN vunid USING +
     "            ENTER ANOTHER ID CODE; TYPE [ENTER] TO LIST THOSE
IN USE:  "
                ENDIF
              ENDIF
              SET VAR vunid TO (ICAP1(.vunid))
            ENDWHILE
            ENTER USING ucompfrm FOR 1 ROW
            ENTER USING upropfrm FOR 1 ROW
          ELSE
            GOTO uniedit
          ENDIF
        ELSE
          SET VAR vunid TO unid IN #1
          EDIT USING ucompfrm WHERE UNINAME EQ .vname
          EDIT USING upropfrm WHERE UNID EQ .vunid
        ENDIF
        DISPLAY mainscr IN menus.pro
        WRITE "DATABASE " AT 2 14 GRAY
        DISPLAY dbasescr IN menus.pro
        WRITE "(2)" AT 7 27 GRAY
        DISPLAY edittyp IN menus.pro
        WRITE "(1)" AT 12 25 GRAY
LABEL uniedit
        CLS FROM 16
        FILLIN vname USING +
           "NAME OF NEXT COMPOSITE TO EDIT (TYPE [ENTER] TO QUIT):
"+
          AT 16 10
      ENDWHILE
```

```
      CLS FROM 16
    ENDIF

*(User elects to edit laminated composites data.  Prompt the user to
enter the name and laminate code of the composite he wishes to edit;
check to see if it is in the database.  If not, allow him to enter it;
otherwise, display the data in an edit form.  Repeat this sequence
until the user elects to stop.)
    IF PICK3 EQ 2 THEN
      CLS FROM 16
      FILLIN vname USING +
        "ENTER THE (UNIDIRECTIONAL) COMPOSITE'S NAME:  " AT 16 10
      WHILE vname EXISTS THEN
        FILLIN vcode USING "ENTER THE LAMINATE CODE:  " AT 17 10
        SET VAR vunid TO unid IN unicomp WHERE uniname EQ .vname
        SET POINTER #1 err1 FOR laminate WHERE lamcode EQ .vcode AND
+
          unid EQ .vunid
        IF err1 NE 0 THEN
          WRITE "THIS MATERIAL HAS NOT YET BEEN ENTERED INTO THE
DATABASE."+
            AT 19 10
          FILLIN vnext=0 USING +
            "TYPE [E] TO ENTER THIS ROW, [C] TO EDIT ANOTHER ROW OR
QUIT." +
            AT 20 10
          IF vnext EQ E THEN
            CLS FROM 18
            WRI "ENTER AN IDENTIFICATION CODE IN THIS FORM: L1, L2."
AT 19 10
            FIL vlamid USI "(TYPE [ENTER] TO LIST THOSE CURRENTLY IN
USE):  "+
              AT 20 10
            SET VAR vlamid TO (ICAP1(.vlamid))
            SET VAR err2 TO 0
            WHILE vlamid FAILS OR err2 EQ 0 THEN
              IF vlamid FAILS THEN
                CLS
                PRINT lamid
                WRITE " "
                SET VAR vct TO COUNT lamid IN laminate
                IF vct GT 20 THEN
                  FILLIN vlamid USING +
          "        ENTER AN ID CODE OR TYPE [ENTER] TO LIST THOSE
IN USE:  "
                ELSE
                  FIL vlamid USI "          ENTER AN IDENTIFICATION
CODE:  "
                ENDIF
              ELSE
                SET POINTER #2 err2 FOR laminate WHERE lamid EQ
.vlamid
                IF err2 EQ 0 THEN
                  WRITE " "
```

```
                        WRITE +
                         "          THIS IDENTIFICATION CODE IS ALREADY
BEING USED."
                        FILLIN vlamid USING +
         "              ENTER ANOTHER ID CODE; TYPE [ENTER] TO LIST THOSE
IN USE:  "
                      ENDIF
                    ENDIF
                    SET VAR vlamid TO (ICAP1(.vlamid))
                  ENDWHILE
                  LOAD laminate
                  .vlamid .vunid .vcode
                  END
                  ENTER USING lpropfrm FOR 1 ROW
                ELSE
                  GOTO lamedit
                ENDIF
              ELSE
                SET VAR vlamid TO lamid IN #1
                EDIT USING lpropfrm WHERE lamid EQ .vlamid
              ENDIF
              DISPLAY mainscr IN menus.pro
              WRITE "DATABASE " AT 2 14 GRAY
              DISPLAY dbasescr IN menus.pro
              WRITE "(2)" AT 7 27 GRAY
              DISPLAY edittyp IN menus.pro
              WRITE "(2)" AT 13 25 GRAY
LABEL lamedit
              CLS FROM 16
              FILLIN vname USING +
                 "COMPOSITE NAME OF NEXT LAMINATE (TYPE [ENTER] TO QUIT):
"+
                AT 16 10
            ENDWHILE
            CLS FROM 16
          ENDIF
          IF PICK3 EQ 3 THEN
            BREAK
          ENDIF
        ENDWHILE
        CLEAR LEVEL3 PICK3
      ENDIF

*(User elects to enter R:BASE directly.  Enter Prompt by Example mode
until user types [Esc].  This returns control to the previous menu.)
  IF PICK2 EQ 3 THEN
    WRITE "PRESS ANY KEY TO ENTER THE R:BASE PROMPT BY EXAMPLE (PBE)"
AT 13 10
    WRITE "MODE.  TO RETURN FROM PBE TO THE DATABASE ACTIONS MENU, "
AT 14 10
    WRITE "PRESS [ESC] AT THE PBE MAIN MENU SCREEN.  " AT 15 10
    PAUSE
    PROMPT
    DISPLAY mainscr IN menus.pro
```

```
    WRITE "DATABASE " AT 2 14 GRAY
  ENDIF
  IF PICK2 EQ 4 THEN
    BREAK
  ENDIF
ENDWHILE
CLEAR vnext vname vunid vlamid vcode err1 err2
CLEAR LEV    PICK2
```

VIEW_RPT.CMD

```
*(VIEW/RPT.CMD:  Generates either views of database data on the screen
or prints database reports to the printer.  Allows the user to select
both a data category and search category.)

*(Define appropriate variables.)
SET VAR PICK2  INTEGER
SET VAR LEVEL2 INTEGER
SET VAR LEVEL2 TO 0
WHILE LEVEL2 EQ 0 THEN
   SET VAR vcon TEXT
   SET VAR vname TEXT
   SET VAR vunid TEXT
   CLS FROM 5

*(Display a menu of data categories for which views are available.)
   IF PICK1 EQ "REPORTS " THEN
      CHOOSE PICK2 FROM report IN menus.pro AT 5
   ELSE
      CHOOSE PICK2 FROM views IN menus.pro AT 5
   ENDIF
   IF PICK2 EQ 0 THEN
      BREAK
   ENDIF

*(User chooses to view unidirectional composites data.  Allow him to
view identification data or property data.)
   IF PICK2 EQ 1 THEN
      SET VAR PICK3 INTEGER
      SET VAR LEVEL3 INTEGER
      SET VAR LEVEL3 TO 0
      WHILE LEVEL3 EQ 0 THEN
         CLS FROM 10
         CHOOSE PICK3 FROM viewtyp IN menus.pro AT 10
*(User chooses to exit program.)
         IF PICK3 EQ 0 OR PICK3 EQ 3 THEN
            BREAK
         ENDIF

*(User elects to view data.  Set up a menu listing search categories.)
         IF PICK3 EQ 1 OR PICK3 EQ 2 THEN
            SET VAR LEVEL4 INTEGER
            SET VAR LEVEL4 TO 0
```

```
            SET VAR PICK4 INTEGER
            WHILE LEVEL4 EQ 0 THEN
               CLS FROM 15
               CHOOSE PICK4 FROM uniview IN menus.pro AT 15
               IF PICK4 EQ 3 THEN
                  BREAK
               ENDIF
               IF PICK4 EQ 0 THEN
                  BREAK
               ENDIF

*(User elects to view all unidirectional composites, insert wildcard
character into search field so that all rows will be printed.)
               IF PICK4 EQ 2 THEN
                  SET VAR vcon TO "*"
               ENDIF

*(User elects to view one class of composites.  List available classes
and allow him to choose one.)
               IF PICK4 EQ 1 THEN
                  CLS
                  SELECT DISTINCT class FROM unicomp
                  WRITE " "
                  FILLIN vcon USING "SELECT A CLASS:  "
               ENDIF

*(Print selected view to the screen, displaying all applicable rows.
If none apply, print an error message and return to the most recent
menu.)
               CLS
               SET POINTER #1 errl FOR unicomp WHERE class EQ .vcon
               IF errl NE 0 THEN
                  WRITE " "
                  WRITE "IMPROPER SELECTION OR NO AVAILABLE DATA.  "
                  WRITE "PRESS ANY KEY TO CONTINUE.  "
                  PAUSE
                  CLS
                  GOTO enduni
               ELSE
                  IF PICK1 EQ "REPORTS " THEN
                     CHANGE RDATA TO "PAGESIZE    60" IN REPORTS WHERE
RNAME +
                        EQ UNID AND RDATA EQ "PAGESIZE    23"
                     CHANGE RDATA TO "PAGESIZE    60" IN REPORTS WHERE
RNAME +
                        EQ UNIRPT AND RDATA EQ "PAGESIZE    23"
                     OUTPUT PRINTER
                  ENDIF
                  IF PICK3 EQ 1 THEN
                     PRINT unid SORTED BY class uniname WHERE class EQ
.vcon
                  ELSE
                     PRINT unirpt SORTED BY class uniname WHERE class
EQ .vcon
```

```
                  ENDIF
                  OUTPUT SCREEN
                  CHANGE RDATA TO "PAGESIZE    23" IN REPORTS WHERE
RNAME EQ +
                     UNID AND RDATA EQ "PAGESIZE    60"
                  CHANGE RDATA TO "PAGESIZE    23" IN REPORTS WHERE
RNAME EQ +
                     UNIRPT AND RDATA EQ "PAGESIZE    60"
               ENDIF
               WRITE " "
               WRITE "PRESS ANY KEY TO CONTINUE.  "
               PAUSE

*(Replace menus on the screen and allow user to view another data
set.)
LABEL enduni
               CLS
               DISPLAY mainscr IN menus.pro AT 1
               IF PICK1 EQ "REPORTS " THEN
                  WRITE "REPORTS " AT 2 34 GRAY
                  DISPLAY reptscr IN menus.pro AT 5
               ELSE
                  WRITE "VIEWS" AT 2 24 GRAY
                  DISPLAY viewscr IN menus.pro AT 5
               ENDIF
               WRITE "(1)" AT 6 25 GRAY
               DISPLAY vtypscr IN menus.pro AT 10
               IF PICK3 EQ 1 THEN
                  WRITE "(1)" AT 11 13 GRAY
               ELSE
                  WRITE "(2)" AT 12 13 GRAY
               ENDIF
            ENDWHILE
            CLEAR PICK4 LEVEL4
         ENDIF
      ENDWHILE
      CLEAR PICK3 LEVEL3
   ENDIF

*(User chooses to view laminated composite data.  Allow him to view
either identification or material property data.)
   IF PICK2 EQ 2 THEN
      SET VAR PICK3 INTEGER
      SET VAR LEVEL3 INTEGER
      SET VAR LEVEL3 TO 0
      WHILE LEVEL3 EQ 0 THEN
         CLS FROM 10
         CHOOSE PICK3 FROM viewtyp IN menus.pro AT 10
*(User chooses to exit program.)
         IF PICK3 EQ 0 OR PICK3 EQ 3 THEN
            BREAK
         ENDIF

*(User elects to view laminates data.  Set up a menu listing search
```

```
categories.)
         IF PICK3 EQ 1 OR PICK3 EQ 2 THEN
            SET VAR LEVEL4 INTEGER
            SET VAR LEVEL4 TO 0
            SET VAR PICK4 INTEGER
            WHILE LEVEL4 EQ 0 THEN
               CLS FROM 15
               CHOOSE PICK4 FROM lamview IN menus.pro AT 15
               IF PICK4 EQ 3 THEN
                  BREAK
               ENDIF
               IF PICK4 EQ 0 THEN
                  BREAK
               ENDIF

*(User elects to view all laminated composites; insert wildcard
character into search field so that all rows will be printed.)
               IF PICK4 EQ 2 THEN
                  SET VAR vcon TO "*"
               ENDIF

*(User elects to view one type of composite.  List available
composites and allow him to choose one.)
               IF PICK4 EQ 1 THEN
                  CLS
                  INTERSECT laminate WITH unicomp FORMING temp USING +
                     unid uniname
                  SELECT DISTINCT uniname FROM temp
                  WRITE " "
                  FILLIN vname USING "SELECT A COMPOSITE:  "
                  REMOVE TABLE temp
                  SET VAR vcon TO unid IN unicomp WHERE uniname EQ
.vname
               ENDIF

*(Print selected view to the screen, displaying all applicable rows.
If none apply, print an error message and return to the most recent
menu.)
               CLS
               SET POINTER #1 err1 FOR laminate WHERE unid EQ .vcon
               IF err1 NE 0 THEN
                  WRITE " "
                  WRITE "IMPROPER SELECTION OR NO AVAILABLE DATA.  "
                  WRITE "PRESS ANY KEY TO CONTINUE.  "
                  PAUSE
                  CLS
                  GOTO endlam
               ELSE
                  IF PICK1 EQ "REPORTS " THEN
                     CHANGE RDATA TO "PAGESIZE    60" IN REPORTS WHERE
RNAME +
                        EQ LAMID AND RDATA EQ "PAGESIZE    23"
                     CHANGE RDATA TO "PAGESIZE    60" IN REPORTS WHERE
RNAME +
```

```
                         EQ LAMRPT AND RDATA EQ "PAGESIZE    23"
                      OUTPUT PRINTER
                   ENDIF
                   IF PICK3 EQ 1 THEN
                      PRINT lamid SORTED BY unid lamcode WHERE unid EQ
.vcon
                   ELSE
                      PRINT lamrpt SORTED BY unid lamcode WHERE unid EQ
.vcon
                   ENDIF
                   OUTPUT SCREEN
                   CHANGE RDATA TO "PAGESIZE    23" IN REPORTS WHERE
RNAME EQ +
                      LAMID AND RDATA EQ "PAGESIZE    60"
                   CHANGE RDATA TO "PAGESIZE    23" IN REPORTS WHERE
RNAME EQ +
                      LAMRPT AND RDATA EQ "PAGESIZE    60"
                ENDIF
                WRITE " "
                WRITE "PRESS ANY KEY TO CONTINUE.  "
                PAUSE

*(Replace menus on the screen and allow user to view another data
set.)
LABEL endlam
                CLS
                DISPLAY mainscr IN menus.pro AT 1
                IF PICK1 EQ "REPORTS " THEN
                   WRITE "REPORTS " AT 2 34
                   DISPLAY reptscr IN menus.pro AT 5
                ELSE
                   WRITE "VIEWS" AT 2 24 GRAY
                   DISPLAY viewscr IN menus.pro AT 5
                ENDIF
                WRITE "(2)" AT 7 25 GRAY
                DISPLAY vtypscr IN menus.pro AT 10
                IF PICK3 EQ 1 THEN
                   WRITE "(1)" AT 11 13 GRAY
                ELSE
                   WRITE "(2)" AT 12 13 GRAY
                ENDIF
             ENDWHILE
             CLEAR PICK4 LEVEL4
          ENDIF
       ENDWHILE
       CLEAR PICK3 LEVEL3
    ENDIF
    IF PICK2 EQ 3 THEN
       BREAK
    ENDIF
ENDWHILE
CLEAR pick2 level2 vcon vname vunid
```

LAM.CMD

```
*(LAM.CMD:  Allows the user to define quasi-isotropic and non-standard
laminates based upon unidirectional ply data stored in the database.
Returns a normalized laminated stiffness matrix and material
properties for each laminate.)

LABEL beglam

*(Define variables for entire routine.)
SET VAR vuni     TEXT
SET VAR vunid    TEXT
SET VAR vex      REAL
SET VAR vey      REAL
SET VAR vnuyx    REAL; *(Stress in x; strain in y--major NU)
SET VAR vnuxy    REAL; *(Stress in y; strain in x--minor NU)
SET VAR vgxy     REAL
SET VAR valpx    REAL
SET VAR valpy    REAL
SET VAR qxx      REAL
SET VAR qyy      REAL
SET VAR qxy      REAL
SET VAR vquasi   TEXT
SET VAR vquit    TEXT
SET VAR vother   TEXT
SET VAR vfiles   INTEGER; *(VFILES equals 1 if called by file
generation prog.)
SET VAR vct      INTEGER
SET VAR vlam     INTEGER
SET VAR vlam     TO 1

LABEL uniloop

*(Prompt user for the unidirectional composite to be used in making
this laminate.  Allow him to type [ENTER] to list all unidirectional
composites in the database.  If he does enter the name of a material,
check to make sure it is in the database; if not, allow him to quit
or retype the composite name.)
CLS FROM 9
WRI "ENTER THE NAME OF THE UNIDIRECTIONAL COMPOSITE IN THIS LAMINATE."
AT 9 10
FILLIN vuni USING "TYPE [ENTER] TO LIST ALL UNIDIRECTIONALS:  " AT 10
10
IF vuni FAILS THEN
   CLS FROM 9
   WRITE " "
   WRITE " "
   PRINT unid SORTED BY uniname
   WRITE " "
   WRITE "PRESS ANY KEY TO CONTINUE"
   PAUSE
   SET VAR vct TO COUNT unid FROM unicomp
   IF vct GT 12 THEN
      CLS
```

```
      DISPLAY mainscr IN menus.pro AT 1
      IF vfiles EQ 1 THEN
         WRITE "FILES " AT 2 54 GRAY
         DISPLAY filescr IN menus.pro AT 5
         WRITE "ANSYS " AT 6 4 GRAY
      ELSE
         WRITE "LAMINATE " AT 2 44 GRAY
      ENDIF
   ELSE
      CLS FROM 9
   ENDIF
   GOTO uniloop
ELSE
   SET POINTER #1 err1 FOR unicomp WHERE uniname EQ .vuni
   SET VAR err2 TO 1
   IF err1 EQ 0 THEN
      SET VAR vunid TO unid IN #1
      SET POINTER #2 err2 FOR uniprop WHERE unid EQ .vunid
   ENDIF
   IF err2 NE 0 THEN
      CLS FROM 9
      WRI "COMPLETE DATA FOR THIS COMPOSITE HAS NOT BEEN ENTERED INTO
" AT 9 10
      WRI "THE DATABASE.  TYPE [Q] TO QUIT, ANY OTHER KEY TO RETYPE "
AT 10 10
      FILLIN vquit=0 USING "THE COMPOSITE NAME. " AT 11 10
      IF vquit EQ Q THEN
         GOTO endlam
      ELSE
         GOTO uniloop
      ENDIF
   ENDIF
ENDIF

*(After locating the appropriate unidirectional composite material in
the database, obtain the necessary material properties and define the
on-axis stiffness matrix.  If any properties are not present, run
FIX.CMD to obtain them or abort processing.)
SET VAR vother TO N
SET VAR vex TO ex IN #2
IF vex FAILS THEN
   SET VAR vrepl TO "EX"
   RUN fix.cmd
   IF vfix NE E THEN
      GOTO rptloop
   ENDIF
ENDIF
SET VAR vey TO ey IN #2
IF vey FAILS THEN
   SET VAR vrepl TO "EY"
   RUN fix.cmd
   IF vfix NE E THEN
      GOTO rptloop
   ENDIF
```

```
ENDIF
SET VAR vnuyx TO nuyx IN #2
IF vnuyx FAILS THEN
   SET VAR vrepl TO "NUYX"
   RUN fix.cmd
   IF vfix NE E THEN
      GOTO rptloop
   ENDIF
ENDIF
SET VAR vgxy TO gxy IN #2
IF vgxy FAILS THEN
   SET VAR vrepl TO "GXY"
   RUN fix.cmd
   IF vfix NE E THEN
      GOTO rptloop
   ENDIF
ENDIF
SET VAR valpx TO alpx IN #2
IF valpx FAILS THEN
   SET VAR vrepl TO "ALPX"
   RUN fix.cmd
   IF vfix NE E THEN
      GOTO rptloop
   ENDIF
ENDIF
SET VAR valpy TO alpy IN #2
IF valpy FAILS THEN
   SET VAR vrepl TO "ALPY"
   RUN fix.cmd
   IF vfix NE E THEN
      GOTO rptloop
   ENDIF
ENDIF

SET VAR vnuxy TO (.vnuyx * .vey / .vex)
SET VAR qxx TO (.vex / (1 - (.vnuxy * .vnuyx)))
SET VAR qyy TO (.vey / (1 - (.vnuxy * .vnuyx)))
SET VAR qxy TO (.vnuyx * .qyy)


*(Allow user to define a quasi-isotropic laminate.  If he elects not
to, skip to the code allowing the user to define a non-standard
layup.)
CLS FROM 9
FILLIN vquasi USING "DO YOU WISH TO DESIGN A QUASI-ISOTROPIC LAMINATE?
(Y/N) "+
  AT 11 10
CLS FROM 9
WHILE vquasi NE Y AND vquasi NE N THEN
   WRITE "INCORRECT RESPONSE.  TRY AGAIN... " AT 10 10
   FIL vquasi USI "DO YOU WISH TO DESIGN A QUASI-ISOTROPIC LAMINATE?
(Y/N) " +
      AT 11 10
   CLS FROM 9
```

```
ENDWHILE

*(If user elects to define a quasi-isotropic laminate, begin by
defining variables for this code segment, and by prompting the user to
enter an ID code.  Allow him to list all currently used ID codes, and
verify that any ID code the user enters is not already being used.)
IF vquasi EQ Y THEN
   SET VAR vlamid  TEXT
   SET VAR vply    INTEGER
   SET VAR vorient REAL
   SET VAR x       REAL
   SET VAR y       REAL
   SET VAR valp1   REAL
   SET VAR valp2   REAL
   SET VAR valp12  REAL
   SET VAR u1      REAL
   SET VAR u4      REAL
   SET VAR u5      REAL
   SET VAR eiso    REAL
   SET VAR nuiso   REAL

LABEL qloop
   WRITE "ENTER AN ID CODE FOR THE LAMINATE IN THIS FORM: L1, L2." AT
10 10
   FILLIN vlamid USING +
      "(TYPE [ENTER] TO LIST ALL CURRENTLY USED ID CODES):  " AT 11 10
   IF vlamid FAILS THEN
      CLS FROM 9
      WRITE " "
      WRITE " "
      PRINT lamid SORTED BY unid
      WRITE " "
      WRITE "PRESS ANY KEY TO CONTINUE."
      PAUSE
      SET VAR vct TO COUNT lamid FROM laminate
      IF vct GT 12 THEN
         CLS
         DISPLAY mainscr IN menus.pro AT 1
         IF vfiles EQ 1 THEN
            WRITE "FILES " AT 2 54 GRAY
            DISPLAY filescr IN menus.pro AT 5
            WRITE "ANSYS " AT 6 4 GRAY
         ELSE
            WRITE "LAMINATE " AT 2 44 GRAY
         ENDIF
      ELSE
         CLS FROM 9
      ENDIF
      GOTO qloop
   ELSE
      SET VAR vlamid TO (ICAP1(.vlamid))
      SET POINTER #1 err1 FOR laminate WHERE lamid EQ .vlamid
      IF err1 EQ 0 THEN
         WRITE "THE ID CODE      IS ALREADY BEING USED. " AT 13 10
```

```
         SHOW VAR vlamid=5 AT 13 22
         WRITE "PRESS ANY KEY CONTINUE.  " AT 14 10
         PAUSE
         CLS FROM 9
         GOTO qloop
      ENDIF
   ENDIF

*(For each of the four orientations of a quasi-isotropic laminate,
run T2.CMD to transform the thermal expansion coefficients properly.
Obtain the average of these values for the laminate properties.)
   SET VAR x TO .valpx
   SET VAR y TO .valpy
   SET VAR vply TO 1
   SET VAR valp1 TO 0
   SET VAR valp2 TO 0
   SET VAR valp12 TO 0
   SET VAR vorient TO 0.0
   WHILE vply LE 4 THEN
      RUN t2.cmd
      SET VAR valp1 TO (.valp1 + .tx)
      SET VAR valp2 TO (.valp2 + .ty)
      SET VAR valp12 TO (.valp12 + .tz)
      SET VAR vply TO (.vply + 1)
      SET VAR vorient TO (.vorient + 45)
   ENDWHILE
   SET VAR valp1  TO (.valp1 / 4)
   SET VAR valp2  TO (.valp2 / 4)
   SET VAR valp12 TO (.valp12 / 4)

*(Solve for the non-zero coefficients of the quasi-isotropic stiffness
matrix; use these values to determine the quasi-isotropic material
properties.)
   SET VAR u1 TO (3*.qxx/8 + 3*.qyy/8 +   .qxy/4 + .vgxy/2)
   SET VAR u4 TO (  .qxx/8 +   .qyy/8 + 3*.qxy/4 - .vgxy/2)
   SET VAR u5 TO (  .qxx/8 +   .qyy/8 -   .qxy/4 + .vgxy/2)
   SET VAR eiso TO (((u1 * u1) - (u4 * u4)) / u1)
   SET VAR nuiso TO (u4 / u1)

*(Print these values to the screen and load them into the database.
Clear the quasi-isotropic values and allow the user to define a
second nonstandard laminate.)
   CLS FROM 9
   WRITE "THE TOTAL STIFFNESS MATRIX FOR THIS COMPOSITE IS: " AT 9 10
   SHOW VAR u1=6  AT 11 20
   SHOW VAR u4=6  AT 11 30
   WRITE "0.0000" AT 11 40
   SHOW VAR u4=6  AT 12 20
   SHOW VAR u1=6  AT 12 30
   WRITE "0.0000" AT 12 40
   WRITE "0.0000" AT 13 20
   WRITE "0.0000" AT 13 30
   SHOW VAR u5=6  AT 13 40
   WRITE "E(iso) = "  AT 15 10
```

```
   SHOW VAR eiso=10    AT 15 19
   WRITE "G(iso) = "   AT 15 32
   SHOW VAR u5=10      AT 15 41
   WRITE "NU(iso) = " AT 15 54
   SHOW VAR nuiso=5    AT 15 64
   LOAD laminate
   .vlamid .vunid "QUASI-ISO"
   END
   LOAD lamprop
   .vlamid .u1 .u4 "0.0" .u1 "0.0" .u5 .eiso .eiso .u5 .nuiso .valp1
.valp2 +
      .valp12
   END
   WRITE "QUASI-ISOTROPIC DATA LOADED INTO DATABASE. " AT 17 10
   WRITE "PRESS ANY KEY TO CONTINUE." AT 18 10
   PAUSE
   CLS FROM 9
   IF vfiles NE 1 THEN
      FILLIN vother USING +
         "DESIGN ANOTHER LAMINATE USING THIS COMPOSITE? (Y/N) " AT 9
10
      CLS FROM 9
   ELSE
      SET VAR vmat TO .vlamid
   ENDIF
   CLEAR u1 u4 u5 eiso nuiso valp1 valp2 valp12 vorient vply x y z
   CLEAR tx ty tz vlamid vply
ELSE
   SET VAR vother TO Y
ENDIF


*(Allow the user to define non-standard layups.  Begin by defining
and initializing appropriate variables, that is, those pertaining to
the entire laminate.)
WHILE vother EQ Y THEN
   SET VAR vlamid TEXT
   SET VAR a11 REAL
   SET VAR a22 REAL
   SET VAR a12 REAL
   SET VAR a16 REAL
   SET VAR a26 REAL
   SET VAR a66 REAL
   SET VAR a11 TO 0
   SET VAR a22 TO 0
   SET VAR a12 TO 0
   SET VAR a16 TO 0
   SET VAR a26 TO 0
   SET VAR a66 TO 0
   SET VAR valp1 REAL
   SET VAR valp2 REAL
   SET VAR valp12 REAL
   SET VAR valp1 TO 0
   SET VAR valp2 TO 0
```

```
   SET VAR valp12 TO 0
   SET VAR lamcode TEXT
   SET VAR vcode TEXT
   SET VAR vtotthk REAL
   SET VAR vtotthk TO 0
   SET VAR deta REAL
   SET VAR e1   REAL
   SET VAR e2   REAL
   SET VAR e6   REAL
   SET VAR nu21 REAL
   SET VAR repeat TEXT
   SET VAR op TEXT
   SET VAR op TO "("
   SET VAR cp TEXT
   SET VAR cp TO ")"
   SET VAR len INTEGER

*(Prompt user for an ID code for the laminate.  Allow him to list all
currently used ID codes.  If user enters an ID code, check that it
hasn't been used for another laminate.)
   WRITE "ENTER AN ID CODE FOR THE LAMINATE IN THIS FORM: L1, L2." AT
10 10
   FILLIN vlamid USING +
      "(TYPE [ENTER] TO LIST ALL CURRENTLY USED ID CODES):  " AT 11 10
   IF vlamid FAILS THEN
      CLS FROM 9
      WRITE " "
      WRITE " "
      PRINT lamid SORTED BY unid
      WRITE " "
      WRITE "PRESS ANY KEY TO CONTINUE."
      PAUSE
      SET VAR vct TO COUNT lamid FROM laminate
      IF vct GT 12 THEN
         CLS
         DISPLAY mainscr IN menus.pro AT 1
         IF vfiles EQ 1 THEN
            WRITE "FILES " AT 2 54 GRAY
            DISPLAY filescr IN menus.pro AT 5
            WRITE "ANSYS " AT 6 4 GRAY
         ELSE
            WRITE "LAMINATE " AT 2 44 GRAY
         ENDIF
      ELSE
         CLS FROM 9
      ENDIF
      GOTO rptloop
   ELSE
      SET VAR vlamid TO (ICAP1(.vlamid))
      SET POINTER #1 err1 FOR laminate WHERE lamid EQ .vlamid
      IF err1 EQ 0 THEN
         WRITE "THE ID CODE      IS ALREADY BEING USED. " AT 13 10
         SHOW VAR vlamid=5 AT 13 22
         WRITE "PRESS ANY KEY CONTINUE.  " AT 14 10
```

```
         PAUSE
         CLS FROM 9
         GOTO rptloop
      ENDIF
   ENDIF

*(Prompt user for a laminate code with which to identify the
composite's layup order.  This laminate code will be used to determine
the thickness and orientation of each layer in the laminate.)
   CLS FROM 9
   WRITE "ENTER THE LAMINATE CODE IN THIS FORM: [0(2)/90]S, [45/-45]2"
AT 9 10
   FILLIN vcode USING " " AT 10 10
   SET VAR lamcode TO .vcode
   SET VAR len TO (SLEN(.vcode))
   SET VAR vcode TO (SGET(.vcode,.len,2))
   SET VAR len TO (.len - 1)
   SET VAR repeat TO Y

*(Define variables pertaining to each layer of the laminate.)
   WHILE repeat EQ Y THEN
      SET VAR q11 REAL
      SET VAR q22 REAL
      SET VAR q12 REAL
      SET VAR q16 REAL
      SET VAR q26 REAL
      SET VAR q66 REAL
      SET VAR x   REAL
      SET VAR y   REAL
      SET VAR xx  REAL
      SET VAR yy  REAL
      SET VAR xy  REAL
      SET VAR zz  REAL
      SET VAR vorient TEXT
      SET VAR vthick  TEXT
      SET VAR slash  INTEGER
      SET VAR open   INTEGER
      SET VAR close  INTEGER
      SET VAR dirlen INTEGER
      SET VAR thklen INTEGER
      SET VAR thkloc INTEGER
      SET VAR strt   INTEGER

*(Obtain the thickness and orientation of each layer of the laminate
by examining the laminate code.  This information will be used to
transform, or rotate, the layer.)
      SET VAR slash TO (SLOC(.vcode,"/"))
      SET VAR open  TO (SLOC(.vcode,.op))
      IF slash EQ 0 THEN
         IF open EQ 0 THEN
            SET VAR close TO (SLOC(.vcode,"]"))
            SET VAR dirlen TO (.close - 1)
            SET VAR vthick TO 1.0
         ELSE
```

```
            SET VAR dirlen TO (.open - 1)
            SET VAR close TO (SLOC(.vcode,.cp))
            SET VAR thklen TO (.close - .open - 1)
            SET VAR thkloc TO (.open + 1)
            SET VAR vthick TO (SGET(.vcode,.thklen,.thkloc))
         ENDIF
         SET VAR vorient TO (SGET(.vcode,.dirlen,1))
         SET VAR repeat TO N
      ELSE
         IF slash LT .open OR open EQ 0 THEN
            SET VAR vthick TO 1.0
            SET VAR dirlen TO (.slash - 1)
         ELSE
            SET VAR close TO (SLOC(.vcode,.cp))
            SET VAR dirlen TO (.open - 1)
            SET VAR thklen TO (.close - .open - 1)
            SET VAR thkloc TO (.open + 1)
            SET VAR vthick TO (SGET(.vcode,.thklen,.thkloc))
         ENDIF
         SET VAR vorient TO (SGET(.vcode,.dirlen,1))
         SET VAR strt TO (.slash + 1)
         SET VAR len TO (.len - .slash)
         SET VAR vcode TO (SGET(.vcode,.len,.strt))
      ENDIF
      SET VAR vorient REAL
      SET VAR vthick  REAL

*(Transform the thermal expansion coefficients of the unidirectional
composite to the appropriate angle by running T2.CMD.  Maintain a sum
of the coefficients by multiplying the value for each layer by the
thickness of that layer and adding it to the previous sum.)
      SET VAR x TO .valpx
      SET VAR y TO .valpy
      RUN t2.cmd
      SET VAR valp1 TO (.valp1 + .tx * .vthick)
      SET VAR valp2 TO (.valp2 + .ty * .vthick)
      SET VAR valp12 TO (.valp12 + .tz * .vthick)
      CLEAR tx ty tz x y z

*(Transform the on-axis stiffness matrix of the unidirectional
composite by running T4.CMD.)
      SET VAR xx TO .qxx
      SET VAR yy TO .qyy
      SET VAR xy TO .qxy
      SET VAR zz TO .vgxy
      RUN t4.cmd
      SET VAR q11 TO .txx
      SET VAR q22 TO .tyy
      SET VAR q12 TO .txy
      SET VAR q16 TO .txz
      SET VAR q26 TO .tyz
      SET VAR q66 TO .tzz
      CLEAR txx tyy txy txz tyz tzz xx yy xy zz
```

```
*(Calculate the total stiffness coefficients for the entire laminate
by multiplying the stiffness coefficients of each layer by the layer
thickness and adding it to the previous sum.  Also maintain the
total thickness of the laminate and increment the layer number.)
      CLS FROM 13
      SET VAR a11 TO (.a11 + .q11 * .vthick)
      SET VAR a22 TO (.a22 + .q22 * .vthick)
      SET VAR a12 TO (.a12 + .q12 * .vthick)
      SET VAR a66 TO (.a66 + .q66 * .vthick)
      SET VAR a16 TO (.a16 + .q16 * .vthick)
      SET VAR a26 TO (.a26 + .q26 * .vthick)
      SET VAR vtotthk TO (.vtotthk + .vthick)
      CLEAR vorient q11 q22 q12 q66 q16 q26 vthick slash open close
      CLEAR dirlen thklen thkloc strt
   ENDWHILE

*(Once all stiffness and thermal expansion coefficients have been
summed, divide the result by the total thickness of the laminate to
determine the weighted average of the coefficients.  Use these values
to calculate the material properties for the laminate.)
   SET VAR valp1 TO (.valp1 / .vtotthk)
   SET VAR valp2 TO (.valp2 / .vtotthk)
   SET VAR valp12 TO (.valp12 / .vtotthk)
   SET VAR a11 TO (.a11 / .vtotthk)
   SET VAR a22 TO (.a22 / .vtotthk)
   SET VAR a12 TO (.a12 / .vtotthk)
   SET VAR a66 TO (.a66 / .vtotthk)
   SET VAR a16 TO (.a16 / .vtotthk)
   SET VAR a26 TO (.a26 / .vtotthk)
   SET VAR deta TO ((.a11*.a22-.a12*.a12)*.a66 + 2*.a12*.a26*.a16)
   SET VAR deta TO (.deta - .a11*.a26*.a26 - .a22*.a16*.a16)
   SET VAR e1 TO (.deta / (.a22 * .a66 - .a26 * .a26))
   SET VAR e2 TO (.deta / (.a11 * .a66 - .a16 * .a16))
   SET VAR e6 TO (.deta / (.a11 * .a22 - .a12 * .a12))
   SET VAR nu21 TO (0 - ((.a16*.a26 - .a12*.a66) / (.a22*.a66 -
.a26*.a26)))

*(Print the stiffness matrix coefficients and resulting material
properties to the screen.  Load the values into the database and allow
the user to define another laminate using this composite or using
another unidirectional composite.)
   CLS FROM 9
   WRITE "THE TOTAL STIFFNESS MATRIX FOR THIS LAMINATE IS: " AT 9 10
   SHOW VAR a11=6 AT 11 20
   SHOW VAR a12=6 AT 11 30
   SHOW VAR a16=6 AT 11 40
   SHOW VAR a12=6 AT 12 20
   SHOW VAR a22=6 AT 12 30
   SHOW VAR a26=6 AT 12 40
   SHOW VAR a16=6 AT 13 20
   SHOW VAR a26=6 AT 13 30
   SHOW VAR a66=6 AT 13 40
   WRITE "E1 = "    AT 15 10
   SHOW VAR e1=8    AT 15 15
```

```
   WRITE "E2 = "     AT 15 27
   SHOW VAR e2=8     AT 15 32
   WRITE "G12 = "    AT 15 44
   SHOW VAR e6=8     AT 15 50
   WRITE "NU21 = "   AT 15 63
   SHOW VAR nu21=5   AT 15 70
   WRITE "WHERE ""1"" IS THE MAJOR AXIS (0° ROTATION) AND ""2"" IS THE
MINOR."+
      AT 17 10

   LOAD laminate
   .vlamid .vunid .lamcode
   END
   LOAD lamprop
   .vlamid .a11 .a12 .a16 .a22 .a26 .a66 .e1 .e2 .e6 .nu21 .valp1
.valp2 +
      .valp12
   END
   WRITE "DATA FOR THIS LAMINATE IS NOW LOADED INTO THE DATABASE. " AT
19 10
   IF vfiles EQ 1 THEN
      WRITE "PRESS ANY KEY TO CONTINUE. " AT 20 10
      PAUSE
      SET VAR vmat TO .vlamid
      SET VAR vother TO N
   ELSE
      FIL vother USING "DESIGN ANOTHER LAMINATE USING THIS COMPOSITE?
(Y/N) "+
         AT 20 10
      CLS FROM 9
   ENDIF
   CLEAR vlamid a11 a12 a16 a22 a26 a66 deta e1 e2 e6 nu21 valp1 valp2
valp12
   CLEAR vtotthk deta vcode vlayers vply repeat op cp len lamcode
LABEL rptloop
ENDWHILE
CLEAR vex vey vnuxy vnuyx vgxy valpx valpy qxx qyy qxy vunid
IF vfiles NE 1 THEN
   FILLIN vquit USING +
     "DESIGN A LAMINATE USING ANOTHER UNIDIRECTIONAL COMPOSITE? (Y/N)
" AT 11 10
   IF vquit EQ Y THEN
      GOTO beglam
   ENDIF
ENDIF
LABEL endlam
CLEAR vother vquit vuni vquasi err1 err2 vct vlam
CLS FROM 9
RETURN
```

T2.CMD

```
SET VAR m  REAL
SET VAR n  REAL
SET VAR m2 REAL
SET VAR n2 REAL
SET VAR mn REAL
SET VAR tx REAL
SET VAR ty REAL
SET VAR tz REAL
SET VAR x  REAL
SET VAR y  REAL
SET VAR z  REAL
IF x FAILS THEN
   SET VAR x TO 0.0
ENDIF
IF y FAILS THEN
   SET VAR y TO 0.0
ENDIF
IF z FAILS THEN
   SET VAR z TO 0.0
ENDIF

SET VAR vorient TO (.vorient * .#pi / 180 )
SET VAR m TO (cos(.vorient))
SET VAR n TO (sin(.vorient))
SET VAR mn   TO (.m * .n)
SET VAR m2   TO (.m * .m)
SET VAR n2   TO (.n * .n)
SET VAR tx TO (.x * .m2 + .y * .n2 + .z * 2 *.mn)
SET VAR ty TO (.x * .n2 + .y * .m2 - .z * 2 *.mn)
SET VAR tz TO (.x * (0 - .mn) + .y * .mn + .z * (.m2 - .n2))
SET VAR vorient TO (.vorient * 180 / .#pi)
CLEAR m n mn m2 n2
```

T4.CMD

```
SET VAR m REAL
SET VAR n REAL
SET VAR m2 REAL
SET VAR n2 REAL
SET VAR m2n2 REAL
SET VAR n3m REAL
SET VAR m3n REAL
SET VAR m4 REAL
SET VAR n4 REAL
SET VAR sqm2n2 REAL
SET VAR txx REAL
SET VAR tyy REAL
SET VAR txy REAL
SET VAR txz REAL
SET VAR tyz REAL
SET VAR tzz REAL
```

```
SET VAR xx REAL
SET VAR yy REAL
SET VAR xy REAL
SET VAR zz REAL
IF xx FAILS THEN
   SET VAR xx TO 0.0
ENDIF
IF yy FAILS THEN
   SET VAR yy TO 0.0
ENDIF
IF xy FAILS THEN
   SET VAR xy TO 0.0
ENDIF
IF zz FAILS THEN
   SET VAR zz TO 0.0
ENDIF

SET VAR vorient TO (.vorient * .#pi / 180)
SET VAR m TO (cos(.vorient))
SET VAR n TO (sin(.vorient))
SET VAR m2n2 TO (.m * .m * .n * .n)
SET VAR m3n  TO (.m * .m * .m * .n)
SET VAR m4   TO (.m * .m * .m * .m)
SET VAR n3m  TO (.m * .n * .n * .n)
SET VAR n4   TO (.n * .n * .n * .n)
SET VAR m2   TO (.m * .m)
SET VAR n2   TO (.n * .n)
SET VAR sqm2n2 TO ((.m2 - .n2) * (.m2 - .n2))
SET VAR txx TO (.xx*.m4 + .yy*.n4 + .xy*2*.m2n2 + .zz*4*.m2n2)
SET VAR tyy TO (.xx*.n4 + .yy*.m4 + .xy*2*.m2n2 + .zz*4*.m2n2)
SET VAR txy TO (.xx*.m2n2 + .yy*.m2n2 + .xy*(.m4+.n4) - .zz*4*.m2n2)
SET VAR tzz TO (.xx*.m2n2 + .yy*.m2n2 - .xy*2*.m2n2 + .zz*.sqm2n2)
SET VAR txz TO (.xx*.m3n - .yy*.n3m + .xy*(.n3m-.m3n)+.zz*2*(.n3m-
.m3n))
SET VAR tyz TO (.xx*.n3m - .yy*.m3n + .xy*(.m3n-.n3m)+.zz*2*(.m3n-
.n3m))
SET VAR vorient TO (.vorient * 180 / .#pi)
CLEAR m n m2n2 m3n n3m n4 m4 m2 n2 sqm2n2
```

FILES.CMD

```
*(FILES.CMD:  Run this subroutine if the user elects to create
interface files.  This program generates an ASCII file of material
property data compatible with the analysis program selected by the
user.)

*(Display a menu of analysis programs for which file development is
available.)
SET VAR PICK2 TEXT
SET VAR LEVEL2 INT
SET VAR LEVEL2 TO 0
WHILE LEVEL2 EQ 0 THEN
  CHOOSE PICK2 FROM files IN menus.pro AT 5
```

```
  IF PICK2 EQ "Esc " THEN
    BREAK
  ENDIF

*(If he selects ANSYS, run ANSFILE.CMD to generate ANSYS compatible
file.)
  IF PICK2 EQ "ANSYS " THEN
    RUN ansfile.cmd
  ENDIF

*(If he selects MAZE, run MAZFILE.CMD to generate MAZE compatible
file.)
  IF PICK2 EQ "MAZE " THEN
    RUN mazfile.cmd
  ENDIF

*(If he selects INGRID...)
  IF PICK2 EQ "INGRID " THEN
  ENDIF
  IF PICK2 EQ "Exit " THEN
    BREAK
  ENDIF
ENDWHILE
CLEAR PICK2 LEVEL2
```

ANSFILE.CMD

```
*(ANSFILE.CMD: Generates ANSYS compatible user file of material data,
either describing a unidirectional composite or a laminate material.
The information on each specific material is placed in a separate
data block identified by an eight digit code name, known as the data
block name.  The data can be accessed through use of the *UFILE and
*USE commands in the ANSYS input file.)

*(Define variables for use in the subroutine.)
SET VAR vfile    TEXT
SET VAR vunict   INTEGER
SET VAR vlamct   INTEGER
SET VAR vmatct   INTEGER
SET VAR vunino   INTEGER
SET VAR vlamno   INTEGER
SET VAR vmatno   INTEGER
SET VAR vfiles   INTEGER
SET VAR vfiles   TO 1
SET VAR vtmpfile TEXT

*(Prompt for a user file name and the number of materials to be
defined.)
CLS FROM 9
FILLIN vfile USING "ENTER A NAME FOR THE ANSYS USER FILE:  " AT 9 10

FIL vunino USING "HOW MANY UNIDIRECTIONAL MATERIALS TO BE DEFINED?  "
AT 11 10
```

```
IF vunino FAILS THEN
   SET VAR vunino TO 0
ENDIF
FILLIN vlamno USING "HOW MANY LAMINATES TO BE DEFINED?  " AT 12 10
IF vlamno FAILS THEN
   SET VAR vlamno TO 0
ENDIF
SET VAR vmatct TO 1
SET VAR vunict TO 1
SET VAR vlamct TO 1
SET VAR vmatno TO (.vunino + .vlamno)
CLS FROM 9

*(If there are unidirectionals to be defined, run ANSUNI.CMD to
gather material file data on each unidirectional composite being
defined and print it to temporary files.)
IF vunino GT 0 THEN
   RUN ansuni.cmd
ENDIF

*(In a similar manner, gather data on laminated composite materials
using subroutine ANSLAM.CMD.)
IF vlamno GT 0 THEN
   RUN anslam.cmd
ENDIF

*(Print actual user file by typing the contents of each temporary data
block file into it.  Delete each of the temporary files after it has
been used.)
OUTPUT .vfile
SET VAR vmatct TO 1
WHILE vmatno GE vmatct THEN
   SET VAR vmatct TEXT
   SET VAR vtmpfile TO ("MAT" + .vmatct)
   SET VAR vmatct INTEGER
   TYPE .vtmpfile
   DELETE .vtmpfile
   SET VAR vmatct TO (.vmatct + 1)
ENDWHILE

*(Clear all variables and return control to the main program.)
OUTPUT SCREEN
CLS FROM 9
WRITE "FILE GENERATION COMPLETE.  PRESS ANY KEY TO CONTINUE. " AT 10
10
PAUSE
CLS FROM 9
CLEAR vfile vmatct vlamct vunict vmatno vlamno vunino vtmpfile vfiles
```

ANSUNI.CMD

```
*(ANSUNI.CMD: Gathers data specific to each unidirectional composite
material being defined and prints it to a temporary data file.)
```

```
*(For each unidirectional material to be defined, repeat the following
sequence of commands, beginning with variable definition.)
WHILE vunino GE vunict THEN
   SET VAR vex       REAL
   SET VAR vey       REAL
   SET VAR vez       REAL
   SET VAR valpx     REAL
   SET VAR valpy     REAL
   SET VAR valpxy    REAL
   SET VAR valpz     REAL
   SET VAR vnuyx     REAL
   SET VAR vnuxy     REAL
   SET VAR vnuyz     REAL
   SET VAR vnuxz     REAL
   SET VAR vdens     REAL
   SET VAR vgxy      REAL
   SET VAR vtransa   REAL
   SET VAR vtranse   REAL
   SET VAR vrepl     TEXT
   SET VAR vtype     TEXT
   SET VAR vorient   REAL
   SET VAR x         REAL
   SET VAR y         REAL
   SET VAR xx        REAL
   SET VAR yy        REAL
   SET VAR xy        REAL
   SET VAR zz        REAL
   SET VAR det       REAL

*(Run UNINAME.CMD to get the name of the unidirectional composite to
be defined.  If the user has elected to define fewer unidirectional
materials than the current material count, exit the subroutine and
begin defining laminated composites.)

   RUN uniname.cmd
   IF vunino LT vunict THEN
      GOTO endrout
   ENDIF

*(Run D_BLOCK.CMD to obtain an appropriate data block name and solid
type from the user.  If VTYPE equals A, the solid type is
axisymmetric; if it equals P, the solid type is 2-dimensional planar.)

   RUN d_block.cmd
   CLS FROM 14

*(Define an ANSYS axisymmetric solid.  First determine whether the
solid is hoop wound or radial.)
   IF vtype EQ A THEN
      SET VAR vtype TO -0-
      FILLIN vtype=0 USING +
        "TYPE [H] IF THE COMPOSITE IS HOOP-WOUND; TYPE [R] IF RADIAL.
" AT 14 10
```

```
      WHILE vtype NE H AND vtype NE R THEN
         WRITE "INCORRECT ANSWER.  TRY AGAIN..." AT 16 10
         FILLIN vtype=0 USING +
         "TYPE [H] FOR HOOP-WOUND; TYPE [R] FOR RADIAL. " AT 17 10
         CLS FROM 16
      ENDWHILE

*(Whether hoop-wound or radial, find the angle of orientation of the
composite fiber.)
      CLS FROM 16
      IF vtype EQ H THEN
         WRI "ENTER THE ANGLE BY WHICH THE COMPOSITE FIBER DIRECTION
IS " +
            AT 16 10
         WRI "ROTATED FROM THE ANSYS GLOBAL HOOP DIRECTION (Z-AXIS).
" AT 17 10
         FIL vorient USI "CONSIDER COUNTER-CLOCKWISE TO BE POSITIVE:
" AT 18 10
      ENDIF
      IF vtype EQ R THEN
         WRI "ENTER THE ANGLE BY WHICH THE COMPOSITE FIBER DIRECTION
IS " +
            AT 16 10
         FILLIN vorient USING +
            "FROM THE ANSYS GLOBAL X-AXIS (COUNTER-CLOCKWISE
POSITIVE):  " +
            AT 17 10
      ENDIF
   ENDIF

*(Define an ANSYS 2-dimensional plane solid.  First prompt the user to
specify the angle of rotation between the composite fibers and the
ANSYS global x-axis.)
   IF vtype EQ P THEN
      WRI "ENTER THE ANGLE BY WHICH THE COMPOSITE FIBER DIRECTION IS
ROTATED" +
         AT 14 10
      FILLIN vorient USING +
         "FROM THE ANSYS GLOBAL X-AXIS (COUNTER-CLOCKWISE POSITIVE):
" AT 15 10
   ENDIF

   CLS FROM 9
   WRITE "CREATING ANSYS DATA BLOCK..." AT 10 10

*(Obtain material property EX from the database.  If the field is
null, allow the user to either enter an approximate value or abort
further processing.)
   SET VAR vex TO ex IN #2
   IF vex FAILS THEN
      SET VAR vrepl TO "EX"
      RUN fix.cmd
      IF vfix NE E THEN
         SET VAR vlamno TO 0
```

```
         GOTO endrout
      ENDIF
   ENDIF

*(Repeat above procedure to obtain material property EY.)
   SET VAR vey TO ey IN #2
   IF vey FAILS THEN
      SET VAR vrepl TO "EY"
      RUN fix.cmd
      IF vfix NE E THEN
         SET VAR vlamno TO 0
         GOTO endrout
      ENDIF
   ENDIF

*(Repeat above procedure to obtain material property NUYX.)
   SET VAR vnuyx TO nuyx IN #2
   IF vnuyx FAILS THEN
      SET VAR vrepl TO "NUYX"
      RUN fix.cmd
      IF vfix NE E THEN
         SET VAR vlamno TO 0
         GOTO endrout
      ENDIF
   ENDIF

*(Repeat above procedure to obtain material property GXY.)
   SET VAR vgxy TO gxy IN #2
   IF vgxy FAILS THEN
      SET VAR vrepl TO "GXY"
      RUN fix.cmd
      IF vfix NE E THEN
         SET VAR vlamno TO 0
         GOTO endrout
      ENDIF
   ENDIF

*(Obtain material property ALPHA X from the database.  If the field is
null, run FIX.CMD allowing the user to enter a value or abort
processing.)
   SET VAR valpx TO alpx IN #2
   IF valpx FAILS THEN
      SET VAR vrepl TO "ALPX"
      RUN fix.cmd
      IF vfix NE E THEN
         SET VAR vlamno TO 0
         GOTO endrout
      ENDIF
   ENDIF

*(Obtain material property ALPHA Y in the same way.)
   SET VAR valpy TO alpy IN #2
   IF valpy FAILS THEN
      SET VAR vrepl TO "ALPY"
```

```
      RUN fix.cmd
      IF vfix NE E THEN
         SET VAR vlamno TO 0
         GOTO endrout
      ENDIF
   ENDIF

*(Obtain DENSITY from the database or from the user.)
   SET VAR vdens TO dens IN #2
   IF vdens FAILS THEN
      SET VAR vrepl TO "DENS"
      RUN fix.cmd
      IF vfix NE E THEN
         SET VAR vlamno TO 0
         GOTO endrout
      ENDIF
   ENDIF

*(Hold transverse direction properties to be used for weak-axis after
rotation.)
   SET VAR vtranse TO .vey
   SET VAR vtransa TO .valpy

*(If rotation of the composite's coordinate system is necessary,
generate on-axis stiffness matrix and transform the values by running
T4.CMD, which performs a fourth rank tensor transform.  Solve for the
transformed material properties.)
   SET VAR vnuxy TO (.vnuyx * .vey / .vex)
   IF vorient NE 0 THEN
      SET VAR zz TO .vgxy
      SET VAR xx TO (.vex / (1 - .vnuxy * .vnuyx))
      SET VAR yy TO (.vey / (1 - .vnuxy * .vnuyx))
      SET VAR xy TO (.vnuyx * .yy)
      RUN t4.cmd
      SET VAR det   TO ((.txx*.tyy - .txy*.txy)*.tzz +
(2*.txy*.tyz*.txz))
      SET VAR det   TO (.det - (.txx*.tyz*.tyz) - (.tyy*.txz*.txz))
      SET VAR vex   TO (.det / (.tyy*.tzz - .tyz*.tyz))
      SET VAR vey   TO (.det / (.txx*.tzz - .txz*.txz))
      SET VAR vgxy  TO (.det / (.txx*.tyy - .txy*.txy))
      SET VAR vnuyx TO (0 - (.txz*.tyz - .txy*.tzz)/(.tyy*.tzz -
.tyz*.tyz))
      SET VAR vnuxy TO (.vnuyx * .vey / .vex)
      CLEAR txx tyy txy txz tyz tzz
   ENDIF

*(If necessary, transform the thermal expansion coefficients using
T2.CMD,
which performs a second-rank tensor transformation.)
   IF vorient NE 0 THEN
      SET VAR x TO .valpx
      SET VAR y TO .valpy
      RUN t2.cmd
      SET VAR valpx  TO .tx
```

```
      SET VAR valpy  TO .ty
      SET VAR valpxy TO .tz
      CLEAR tx ty tz
   ENDIF

*(If hoop-wound, change the x-y axis properties to y-z axis
properites.)
   IF vtype EQ H THEN
      SET VAR vez TO .vex
      SET VAR vgxy TEXT
      SET VAR vgxy TO ***
      SET VAR vnuyz TO .vnuyx
      SET VAR vnuxy TEXT
      SET VAR vnuxy TO ***
      SET VAR vnuxz TEXT
      SET VAR vnuxz TO ***
      SET VAR valpz TO .valpx
      SET VAR valpx TO .vtransa
      SET VAR vex TO .vtranse
   ENDIF

*(If radial, set hoop properties to those of the minor unidirectional
axis.)
   IF vtype EQ R THEN
      SET VAR vez TO .vtranse
      SET VAR valpz TO .vtransa
      SET VAR vnuyz TEXT
      SET VAR vnuyz TO ***
      SET VAR vnuxz TEXT
      SET VAR vnuxz TO ***
   ENDIF

*(Run ANSFGEN.CMD to generate a temporary file containing a data block
of material properties for the material being defined.)
   RUN ansfgen.cmd

*(Prepare for further iterations by incrementing counts and clearing
variables.)
   CLS FROM 9
   SET VAR vmatct TO (.vmatct + 1)
   SET VAR vunict TO (.vunict + 1)
   CLEAR vex vey vez valpx valpy valpxy valpz vnuxy vnuyx vnuyz vnuxz
vdens +
      vgxy vrepl vtype vorient det vfix zz xx yy xy x y vmat vtransa
vtranse
ENDWHILE
LABEL endrout
```

ANSLAM.CMD

```
*(ANSLAM.CMD: Gathers data specific to each laminated composite
material being defined and prints it to a temporary data file.)
```

```
*(For each laminated material to be defined, repeat the following
sequence of commands, beginning with variable definition.)
WHILE vlamno GE vlamct THEN
   SET VAR vex       REAL
   SET VAR vey       REAL
   SET VAR vez       REAL
   SET VAR valpx     REAL
   SET VAR valpy     REAL
   SET VAR valpxy    REAL
   SET VAR valpz     REAL
   SET VAR vnuyx     REAL
   SET VAR vnuxy     REAL
   SET VAR vnuyz     REAL
   SET VAR vnuxz     REAL
   SET VAR vdens     REAL
   SET VAR vgxy      REAL
   SET VAR vtransa   REAL
   SET VAR vtranse   REAL
   SET VAR vfix      TEXT
   SET VAR vrepl     TEXT
   SET VAR vtype     TEXT
   SET VAR vunid     TEXT

*(Run LAMNAME.CMD to get the name of the laminated composite to
be defined.  If the usesr has elected to define fewer laminated
materials than the current count, exit the subroutine.)

   RUN lamname.cmd
   IF vlamno LT vlamct THEN
      GOTO endrout
   ENDIF

*(Run D_BLOCK.CMD to obtain an appropriate data block name and solid
type from the user.  If VTYPE equals A, then the solid type is
axisymmetric; if it equals P, the solid type is 2-dimensional planar.)

   RUN d_block.cmd

*(Define an ANSYS axisymmetric solid.  First determine whether the
solid is hoop-wound or radial.)
   IF vtype EQ A THEN
      SET VAR vtype TO -0-
      FILLIN vtype=0 USING +
        "TYPE [H] IF THE COMPOSITE IS HOOP-WOUND; TYPE [R] IF RADIAL.
" AT 14 10
      WHILE vtype NE H AND vtype NE R THEN
         WRITE "INCORRECT ANSWER.  TRY AGAIN..." AT 16 10
         FILLIN vtype=0 USING +
            "TYPE [H] FOR HOOP-WOUND; TYPE [R] IF RADIAL. " AT 17 10
         CLS FROM 16
      ENDWHILE
   ENDIF

   CLS FROM 9
```

```
   WRITE "CREATING ANSYS DATA BLOCK..." AT 10 10

*(Obtain material property E1 from the database.  Note that 1 refers
to the major axis and 2 refers to the minor axis.)
   SET VAR vex TO e1 IN #2

*(Obtain material property E2 from the database.)
   SET VAR vey TO e2 IN #2

*(Obtain material property NU21 from the database.)
   SET VAR vnuyx TO nu21 IN #2
   SET VAR vnuxy TO (.vnuyx * .vey / .vex)

*(Obtain material property G12 from the database.)
   SET VAR vgxy TO g12 IN #2

*(Obtain material properties ALPHA 1, ALPHA 2, and ALPHA 12 from
database.)
   SET VAR valpx TO alp1 IN #2
   SET VAR valpy TO alp2 IN #2
   SET VAR valpxy TO alp12 IN #2

*(Obtain material property DENSITY from the database.)
   SET VAR vunid TO unid IN laminate WHERE lamid EQ .vmat
   SET VAR vdens TO dens IN uniprop WHERE unid EQ .vunid
   IF vdens FAILS THEN
      SET VAR vrepl TO "DENS"
      RUN fix.cmd
      IF vfix NE E THEN
         GOTO endrout
      ENDIF
   ENDIF

*(Gather transverse direction properties to be used for weak-axis of
axisymmetric solid.)
   IF vtype EQ H OR vtype EQ R THEN
      SET VAR vtranse TO ey IN uniprop WHERE unid EQ .vunid
      IF vtranse FAILS THEN
         SET VAR vrepl TO "Ethick"
         RUN fix.cmd
         IF vfix NE E THEN
            GOTO endrout
         ELSE
            SET VAR vtranse TO .vethick
         ENDIF
      ENDIF
      SET VAR vtransa TO alpy IN uniprop WHERE unid EQ .vunid
      IF vtransa FAILS THEN
         SET VAR vrepl TO "ALPthck"
         RUN fix.cmd
         IF vfix NE E THEN
            GOTO endrout
         ELSE
            SET VAR vtransa TO .valpthck
```

```
         ENDIF
      ENDIF

*(For hoop-wound composites, change x-y plane properties to x-z plane;
let x-axis take transverse direction properties.)
      IF vtype EQ H THEN
         SET VAR vez TO .vex
         SET VAR vgxy TEXT
         SET VAR vgxy TO ***
         SET VAR vnuxy TEXT
         SET VAR vnuxy TO ***
         SET VAR vnuxz TEXT
         SET VAR vnuxz TO ***
         SET VAR vnuyz TO .vnuyx
         SET VAR valpz TO .valpx
         SET VAR valpx TO .vtransa
         SET VAR vex TO .vtranse
      ENDIF
*(For radial composites, x-y properties remain the same, z-axis
takes on transverse direction properties.)
      IF vtype EQ R THEN
         SET VAR vez TO .vtranse
         SET VAR valpz TO .vtransa
         SET VAR vnuyz TEXT
         SET VAR vnuyz TO ***
         SET VAR vnuxz TEXT
         SET VAR vnuxz TO ***
      ENDIF
   ENDIF

*(For either axisymmetric or 2-d solid, run ANSFGEN.CMD to create a
temporary file containing one data block of material properties.)
   RUN ansfgen.cmd

*(Prepare for further iterations by incrementing material count and
clearing variables.)
   SET VAR vmatct TO (.vmatct + 1)
   SET VAR vlamct TO (.vlamct + 1)
   CLEAR vex vey vez valpx valpy valpxy valpz vnuxy vnuyx vnuyz vnuxz
vdens +
      vgxy vrepl vtype vorient vfix vunid vmat vtranse vtransa
ENDWHILE
LABEL endrout
```

LAMNAME.CMD

```
*(LAMNAME.CMD:  Run from ANSLAM.CMD and MAZLAM.CMD to obtain the name
of the laminated composite to be defined.)

SET VAR vuse   TEXT
SET VAR vmat   TEXT
SET VAR err1   INTEGER
SET VAR err2   INTEGER
```

```
SET VAR vtemp  INTEGER
SET VAR vdec   TEXT
SET VAR vct    INTEGER
SET VAR vins   TEXT

*(Prompt for the name of the laminated composite being defined,
allowing the user to define a new ocmposite or list all existing
laminates.)
LABEL looptop
WRITE "DEFINING LAMINATED COMPOSITE NUMBER    OF   ..... " AT 11 10
SHOW VAR vlamct=2 AT 11 46
SHOW VAR vlamno=2 AT 11 52
IF vlamct EQ 1 THEN
WRITE "NOTE: IF THE ANSYS/MAZE GLOBAL COORDINATE SYSTEM IS DIFFERENT "
AT 12 10
WRITE "THAN THE MAJOR AND MINOR AXES OF THE LAMINATE YOU WISH TO USE,"
AT 13 10
WRI "YOU MUST EXIT THIS ROUTINE AND USE ""LAMINATE"" TO DEFINE A NEW "
AT 14 10
WRI "LAYUP WITH THE PROPER ORIENTATION.  ALL PREVIOUSLY DEFINED " AT
15 10
WRI "MATERIALS WILL BE SAVED.  FOR EXAMPLE, IF A [0/90] LAMINATE IS "
AT 16 10
WRI "TO BE SITUATED AT A 7 DEGREE ANGLE FROM THE GLOBAL X-AXIS,
DEFINE" AT 17 10
WRI "A [7/97] LAMINATE INSTEAD.  QUASI-ISOTROPIC LAMINATES DO NOT
NEED" AT 18 10
WRI "TO BE ORIENTED AT ANY PARTICULAR ANGLE." AT 19 10
WRI "TYPE [E] TO USE AN EXISTING LAMINATE; TYPE [D] TO EXIT AND
DEFINE" AT 21 10
FIL vuse=0 USI "A NEW ONE; TYPE [ENTER] TO LIST CURRENTLY DEFINED
LAMINATES. " +
   AT 22 10
ELSE
WRI "TYPE [E] TO USE AN EXISTING LAMINATE; TYPE [D] TO EXIT AND
DEFINE" AT 13 10
FIL vuse=0 USI "A NEW ONE; TYPE [ENTER] TO LIST CURRENTLY DEFINED
LAMINATES. "+
   AT 14 10
ENDIF
*(If user types [E], allow him to enter a material name.  Check to see
if it is in the database.  If not, proint an error message allowing
him to define one less material than originally specified.  After
processing of this data block, skip remaining code and return to
previous prompt.)
IF vuse EQ E THEN
   CLS FROM 12
   FILLIN vmat USING "ENTER THE LAMINATE ID CODE:  " AT 13 10
   SET VAR vmat TO (ICAP1(.vmat))
   SET POINTER #1 err1 FOR laminate WHERE lamid EQ .vmat
   SET VAR err2 TO 1
   IF err1 EQ 0 THEN
      SET POINTER #2 err2 FOR lamprop WHERE lamid EQ .vmat
   ENDIF
```

```
    IF err2 NE 0 THEN
       CLS FROM 9
       WRITE "NO MATERIAL              IS LISTED. " AT 9 10
       SHOW VAR vmat AT 9 22
       WRITE "DO YOU WISH TO DEFINE ONLY    LAMINATES? (Y/N) " AT 10 10
       SET VAR vtemp TO (.vlamno - 1)
       SHOW VAR vtemp=2 AT 10 37
       FILLIN vdec USING " " AT 10 56
       IF vdec EQ Y THEN
          SET VAR vlamno TO vtemp
          SET VAR vmatno TO vtemp
       ENDIF
       CLS FROM 9
       IF vlamno GE vlamct THEN
          GOTO looptop
       ENDIF
    ENDIF
 ELSE

 *(If the user types [D], run subroutine LAM.CMD allowing him to define
 a new laminate.  The ID code of that laminate is then used as the
 material identifier in this code.)
    IF vuse EQ D THEN
       SET VAR vmatno TO (.vmatct - 1)
       SET VAR vlamno TO 0
    ELSE

 *(If the user types neither [E] nor [D], then list all available
 laminates and return to the previous prompt.)
       CLS FROM 8
       SET VAR vins TO " "; SHOW VAR vins AT 7 1
       PRINT lamid SORTED BY unid
       WRITE " "
       WRITE "PRESS ANY KEY TO CONTINUE."
       PAUSE
       SET VAR vct TO COUNT lamid FROM laminate
       IF vct GT 12 THEN
          CLS
          DISPLAY mainscr IN menus.pro AT 1
          WRITE "FILES" AT 2 54 GRAY
          DISPLAY filescr IN menus.pro AT 5
          WRITE "ANSYS" AT 6 4 GRAY
       ELSE
          CLS FROM 8
       ENDIF
       GOTO looptop
    ENDIF
 ENDIF
 CLEAR vins vct err1 err2 vtemp vdec vuse
```

UNINAME.CMD

```
*(UNINAME.CMD:  Run from ANSUNI.CMD and MAZUNI.CMD to obtain the name
of the unidirectional composite to be defined.)

SET VAR vmat  TEXT
SET VAR vins  TEXT
SET VAR vct   INTEGER
SET VAR vunid TEXT
SET VAR vtemp INTEGER
SET VAR vdec  TEXT
SET VAR err1  INTEGER
SET VAR err2  INTEGER

*(Prompt for the name of the unidirectional composite being defined,
allowing the user to list all materials by typing [ENTER].)
LABEL looptop
WRITE "ENTER THE NAME OF UNIDIRECTIONAL COMPOSITE NUMBER    OF   ." AT
11 10
SHOW VAR vunict=2 AT 11 60
SHOW VAR vunino=2 AT 11 66
FILLIN vmat USING "(TYPE [ENTER] TO LIST ALL UNIDIRECTIONALS):  " AT
12 10
SET VAR vmat TO (ICAP1(.vmat))
IF vmat FAILS THEN
   CLS FROM 8
   SET VAR vins TO " "; SHOW VAR vins AT 7 1
   PRINT unid SORTED BY uniname
   WRITE " "
   WRITE "PRESS ANY KEY TO CONTINUE."
   PAUSE
   SET VAR vct TO COUNT uniname FROM unicomp
   IF vct GT 12 THEN
      CLS
      DISPLAY mainscr IN menus.pro AT 1
      WRITE "FILES" AT 2 54 GRAY
      DISPLAY filescr IN menus.pro AT 5
      WRITE "ANSYS" AT 6 4 GRAY
   ELSE
      CLS FROM 8
   ENDIF
   GOTO looptop
ELSE

*(If a material name is entered, check to see if it is listed in the
database.  If not, print an error message and allow user to define one
less material than he originally stated.  Abort further processing of
this data block, skipping the remaining code and returning to previous
prompt.)
   SET POINTER #1 err1 FOR unicomp WHERE uniname EQ .vmat
   SET VAR err2 TO 1
   IF err1 EQ 0 THEN
      SET VAR vunid TO unid IN #1
      SET POINTER #2 err2 FOR uniprop WHERE unid EQ .vunid
```

```
   ENDIF
   IF err2 NE 0 THEN
      CLS FROM 9
      WRITE "NO MATERIAL                  IS LISTED. " AT 9 10
      SHOW VAR vmat AT 9 22
      WRITE "DO YOU WISH TO DEFINE ONLY    UNIDIRECTIONALS? (Y/N) " AT
10 10
      SET VAR vtemp TO (.vunino - 1)
      SHOW VAR vtemp=2 AT 10 37
      FILLIN vdec USING " " AT 10 62
      IF vdec EQ Y THEN
         SET VAR vunino TO vtemp
         SET VAR vmatno TO vtemp
      ENDIF
      CLS FROM 9
      IF vunino GE vunict THEN
         GOTO looptop
      ENDIF
   ENDIF
ENDIF
CLEAR vins vct err1 err2 vdec vtemp vunid
```

D_BLOCK.CMD

```
*(D_BLOCK.CMD: Obtains an appropriate data block name and ANSYS solid
type (plane or axisymmetric) from the user.)

SET VAR vnamlen INTEGER
SET VAR vchange TEXT
SET VAR vmatnam TEXT
SET VAR vtype   TEXT

*(If the name or ID code from the database is too long, prompt the use
to enter a shorter name; otherwise, allow him to chang the name as
desired.)
SET VAR vnamlen TO (SLEN(.vmat))
IF vnamlen GT 8 THEN
   WRITE "THE DATA BLOCK NAME FOR MATERIAL              MUST BE LESS"
+
      AT 14 10
   SHOW VAR vmat AT 14 43
   FIL vmatnam USI "THAN EIGHT CHARACTERS.  ENTER A DATA BLOCK NAME:
" +
      AT 15 10
ELSE
   WRITE "SHOULD THE DATA BLOCK NAME FOR              BE DIFFERENT
THAN" +
      AT 14 10
   SHOW VAR vmat AT 14 41
   FILLIN vchange USING "THE PREVIOUSLY ENTERED NAME/ID CODE? (Y/N) "
AT 15 10
   IF vchange EQ Y THEN
```

```
      FIL vmatnam USING "ENTER A DATA BLOCK NAME (UP TO EIGHT CHARS):
" +
         AT 17 10
   ELSE
      SET VAR vmatnam TO .vmat
   ENDIF
ENDIF
SET VAR vnamlen TO (SLEN(.vmatnam))
WHILE vnamlen GT 8 THEN
   WRITE "DATA BLOCK NAME MUST BE FEWER THAN NINE CHARACTERS." AT 19
10
   FIL vmatnam USING "ENTER ANOTHER DATA BLOCK NAME:  " AT 20 10
   SET VAR vnamlen TO (SLEN(.vmatnam))
   CLS FROM 19
ENDWHILE
SET VAR vmatnam TO (LUC(.vmatnam))

*(Allow the user to specify the ANSYS solid type for which he is
defining the material.)
CLS FROM 9
WRITE "TYPE [P] IF DEFINING A 2-DIMENSIONAL PLANE SOLID IN THE "  AT
10 10
WRITE "X-Y PLANE; TYPE [A] IF DEFINING AN AXISYMMETRIC SOLID WITH " AT
11 10
WRITE "SYMMETRY AROUND THE Y-AXIS IN THE Z-DIRECTION. " AT 12 10
FILLIN vtype=0 USING " " AT 13 10
WHILE vtype NE P AND vtype NE A THEN
   CLS FROM 14
   WRITE "INCORRECT SELECTION.  TRY AGAIN..." AT 14 10
   FIL vtype=0 USING "TYPE [P] FOR PLANAR; [A] FOR AXISYMMETRIC.  " AT
15 10
ENDWHILE
CLEAR vnamlen vchange
```

ANSFGEN.CMD

```
*(ANSFGEN.CMD:  This subroutine, run from ANSLAM.CMD and ANSUNI.CMD
generates a temporary file containing a data block of either
unidirectional or laminated composite material data.)

SET VAR vcom      TEXT
SET VAR vdot      INTEGER
SET VAR vkeep     INTEGER
SET VAR vdata     TEXT

*(Allow user to enter an explanatory comment line describing the
material being defined.)
CLS FROM 12
WRITE "IF DESIRED, ENTER A COMMENT LINE TO BE ADDED TO THE DATA" AT 12
10
WRITE "BLOCK DESCRIBING THE MATERIAL; TYPE [ENTER] FOR NONE. " AT 13
10
FILLIN vcom USING ">" AT 14 10
```

```
CLS FROM 12

*(Open a temporary file for the data block.  The first code after the
data block name and user comment line is a header of ANSYS commands
which allows the data to be applied to more than one material within
ANSYS.)
SET VAR vmatct TEXT
SET VAR vtmpfile TO ("MAT" + .vmatct)
SET VAR vmatct INTEGER
OUTPUT .vtmpfile
WRITE .vmatnam

*(Write the user specified comment line to the temporary file.)
IF vcom EXISTS THEN
   SET VAR vcom TO ("C***" & .vcom)
   WRITE .vcom
ENDIF
WRITE "C*** "
WRITE "C*** The following data block defines material prop- "
WRITE "C*** erties for the above listed composite material. "
WRITE "C*** "
WRITE "*SET,AR10,ARG1 "
WRITE "*IF,ARG2,GT,0,HERE,2 "
WRITE "*SET,ARG2,ARG1 "
WRITE "*IF,ARG3,GT,0,HERE,2 "
WRITE "*SET ARG3,1 "

*(Generate the data block line corresponding to ANSYS material
property EX by truncating the previously obtained value to six
characters past the decimal place and concatenating it to the
appropriate ANSYS material property command.  The line of code thus
generated is then written to the temporary file.  Each material
property is specified in a similar manner.)
SET VAR vex TEXT
SET VAR vdot TO (SLOC(.vex,"."))
SET VAR vkeep TO (.vdot + 6)
SET VAR vex TO (SGET(.vex,.vkeep,1))
SET VAR vdata TO ("MP,EX,AR10," + .vex)
WRITE .vdata

*(Generate the data block line corresponding to material property EY.)
SET VAR vey TEXT
SET VAR vdot TO (SLOC(.vey,"."))
SET VAR vkeep TO (.vdot + 6)
SET VAR vey TO (SGET(.vey,.vkeep,1))
SET VAR vdata TO ("MP,EY,AR10," + .vey)
WRITE .vdata

*(If axisymmetric, generate data block line corresponding to material
property EZ.)
IF vtype EQ R OR vtype EQ H THEN
   SET VAR vez TEXT
   SET VAR vdot TO (SLOC(.vez,"."))
   SET VAR vkeep TO (.vdot + 6)
```

```
   SET VAR vez TO (SGET(.vez,.vkeep,1))
   SET VAR vdata TO ("MP,EZ,AR10," + .vez)
   WRITE .vdata
ENDIF

*(Generate the data block line corresponding to material property
ALPHA X.)
SET VAR valpx TEXT
SET VAR vdot TO (SLOC(.valpx,"."))
SET VAR vkeep TO (.vdot + 6)
SET VAR valpx TO (SGET(.valpx,.vkeep,1))
SET VAR vdata TO ("MP,ALPX,AR10," + .valpx)
WRITE .vdata

*(Generate the data block line corresponding to material property
ALPHA Y.)
SET VAR valpy TEXT
SET VAR vdot TO (SLOC(.valpy,"."))
SET VAR vkeep TO (.vdot + 6)
SET VAR valpy TO (SGET(.valpy,.vkeep,1))
SET VAR vdata TO ("MP,ALPY,AR10," + .valpy)
WRITE .vdata

*(If axisymmetric, generate data block line corresponding to material
property ALPHA Z.)
IF vtype EQ R OR vtype EQ H THEN
   SET VAR valpz TEXT
   SET VAR vdot TO (SLOC(.valpz,"."))
   SET VAR vkeep TO (.vdot + 6)
   SET VAR valpz TO (SGET(.valpz,.vkeep,1))
   SET VAR vdata TO ("MP,ALPZ,AR10," + .valpz)
   WRITE .vdata
ENDIF

*(Generate the data block line corresponding to material property NU
XY.)
SET VAR vnuxy TEXT
SET VAR vdot TO (SLOC(.vnuxy,"."))
SET VAR vkeep TO (.vdot + 6)
SET VAR vnuxy TO (SGET(.vnuxy,.vkeep,1))
SET VAR vdata TO ("MP,NUXY,AR10," + .vnuxy)
WRITE .vdata

*(If axisymmetric, generate data block line corresponding to material
property NU YZ.)
IF vtype EQ R OR vtype EQ H THEN
   SET VAR vnuyz TEXT
   SET VAR vdot TO (SLOC(.vnuyz,"."))
   SET VAR vkeep TO (.vdot + 6)
   SET VAR vnuyz TO (SGET(.vnuyz,.vkeep,1))
   SET VAR vdata TO ("MP,NUYZ,AR10," + .vnuyz)
   WRITE .vdata
ENDIF
```

```
*(If axisymmetric, generate data block line corresponding to material
property NU XZ.)
IF vtype EQ R OR vtype EQ H THEN
   SET VAR vnuxz TEXT
   SET VAR vdot TO (SLOC(.vnuxz,"."))
   SET VAR vkeep TO (.vdot + 6)
   SET VAR vnuxz TO (SGET(.vnuxz,.vkeep,1))
   SET VAR vdata TO ("MP,NUXZ,AR10," + .vnuxz)
   WRITE .vdata
ENDIF

*(Generate the data block line corresponding to material property
DENSITY.)
SET VAR vdens TEXT
SET VAR vdot TO (SLOC(.vdens,"."))
SET VAR vkeep TO (.vdot + 6)
SET VAR vdens TO (SGET(.vdens,.vkeep,1))
SET VAR vdata TO ("MP,DENS,AR10," + .vdens)
WRITE .vdata

*(Generate the data block line corresponding to material property G
XY.)
SET VAR vgxy TEXT
SET VAR vdot TO (SLOC(.vgxy,"."))
SET VAR vkeep TO (.vdot + 6)
SET VAR vgxy TO (SGET(.vgxy,.vkeep,1))
SET VAR vdata TO ("MP,GXY,AR10," + .vgxy)
WRITE .vdata

*(End the data block with further ANSYS commands supporting variable
processing of the data block.)
WRITE "*IF,AR10,GE,ARG2,HERE,3 "
WRITE "*SET,AR10,AR10+ARG3 "
WRITE "*GO,,10 "
WRITE "/EOF "
WRITE " "

OUTPUT SCREEN
CLS FROM 9
WRITE "DATA BLOCK COMPLETE.  PRESS ANY KEY TO CONTINUE. " AT 10 10
PAUSE
CLS FROM 9
CLEAR vcom vdot vkeep vdata vmatnam
```

FIX.CMD

```
*(FIX.CMD:  Runs if a necessary material property cannot be located in
the database.  Prints out an error message and allows the user to
choose an action.  Possible options are entering a value, marking the
property or aborting the process.)

*(Print out error message and prompt.)
SET VAR vshow TEXT
```

```
SET VAR vfix  TEXT
SET VAR vrepl TEXT
SET VAR vlam  INTEGER; *(VLAM is 1 if generating a layup (called by
LAM.CMD).)
OUTPUT SCREEN
WRITE " "
SET VAR vshow TO ("ERROR: NO VALUE WAS FOUND IN THE DATABASE FOR
PROPERTY")
SET VAR vshow TO (.vshow & .vrepl)
WRITE .vshow AT 16 5
WRI "TYPE [E] TO ENTER THE VALUE MANUALLY, ANYTHING ELSE TO ABORT
FURTHER" +
   AT 17 5
IF vlam EQ 1 THEN
   FIL vfix=0 USI "PROCESSING OF THIS LAMINATE." AT 18 5
ELSE
   FIL vfix=0 USI "PROCESSING.  MATERIALS DEFINED PREVIOUSLY WILL BE
SAVED. " +
      AT 18 5
ENDIF

*(Perform appropriate action, prompt for variable, mark the property
or print an "aborting process" message.)
IF vfix EQ E THEN
   SET VAR vrepl TO ("v" + .vrepl)
   FILLIN .vrepl USING "ENTER NEW VALUE:  " AT 20 5
ELSE
   CLS FROM 9
   IF vlam EQ 1 THEN
      WRITE "ABORTING LAMINATE GENERATION.  PRESS ANY KEY TO
CONTINUE." AT 10 10
   ELSE
      WRITE "ABORTING FILE GENERATION PROCESS.  PRESS ANY KEY TO
CONTINUE." +
         AT 10 10
   ENDIF
   PAUSE
ENDIF
CLEAR vshow vrepl
CLS FROM 9
```

MAZFILE.CMD

```
*(MAZFILE.CMD:  Generates a material data file compatible with the
MAZE preprocessor for several finite element analysis programs.  This
file must be merged into an existing MAZE input file.  Each material
is identified by an integer ID code, which can be defined by the user
to coordinate with the input file.)

*(Define apprpriate variables.)
SET VAR vfile    TEXT
SET VAR vmatct   INTEGER
SET VAR vmatno   INTEGER
```

```
SET VAR vunict   INTEGER
SET VAR vunino   INTEGER
SET VAR vlamct   INTEGER
SET VAR vlamno   INTEGER
SET VAR vfiles   INTEGER
SET VAR vfiles   TO 1
SET VAR vtmpfile TEXT

*(Prompt user for the name of the material file and the number of
unidirectional and laminated materials to be defined.)
CLS FROM 9
FILLIN vfile USING "ENTER THE NAME OF THE MAZE MATERIAL FILE:  " AT 9
10
FILLIN vunino USING "HOW MANY UNIDIRECTIONALS TO BE DEFINED?  " AT 11
10
IF vunino FAILS THEN
   SET VAR vunino TO 0
ENDIF
FILLIN vlamno USING "HOW MANY LAMINATES TO BE DEFINED?  " AT 12 10
IF vlamno FAILS THEN
   SET VAR vlamno TO 0
ENDIF
SET VAR vmatct TO 1
SET VAR vunict TO 1
SET VAR vlamct TO 1
SET VAR vmatno TO (.vunino + .vlamno)
CLS FROM 9

*(If there are unidirectionals or laminates to be defined, run subrou-
tines MAZUNI.CMD and MAZLAM.CMD, respectively, to generate temporary
files containing material property data for each material of concern.)
WRITE "NOTE: MATERIALS WILL BE NUMBERED CONSECUTIVELY FROM 1 TO " AT 9
10
SHOW VAR vmatno=2 AT 9 67
WRITE "IN THE ORDER THAT THEY ARE DEFINED.  PLEASE ENSURE THAT THIS "
AT 10 10
WRITE "IS CONSISTENT WITH THE NUMBERING CONVENTION USED ELSEWHERE IN "
AT 11 10
WRITE "THE MAZE INPUT FILE.  PRESS ANY KEY TO CONTINUE. " AT 12 10
PAUSE
CLS FROM 9
IF vunino GT 0 THEN
   RUN mazuni.cmd
ENDIF
IF vlamno GT 0 THEN
   RUN mazlam.cmd
ENDIF

*(Generate the actual material file by printing each temporary file
into it.  Delete the temporary files after they have been used.)
OUTPUT .vfile
SET VAR vmatct TO 1
WHILE vmatno GE vmatct THEN
   SET VAR vmatct TEXT
```

```
   SET VAR vtmpfile TO ("MAT" + .vmatct)
   SET VAR vmatct INTEGER
   TYPE .vtmpfile
   DELETE .vtmpfile
   SET VAR vmatct TO (.vmatct + 1)
ENDWHILE

*(Clear all variables and return control to the main program.)
OUTPUT SCREEN
CLS FROM 9
WRITE "FILE GENERATION COMPLETE.  PRESS ANY KEY TO CONTINUE. " AT 10
10
PAUSE
CLS FROM 9
CLEAR vfile vmatct vmatno vunict vunino vlamct vlamno vtmpfile
```

MAZUNI.CMD

```
*(MAZUNI.CMD:  Gathers data specific to each unidirectional composite
material being defined in MAZE and prints it to a temporary data
file.)

*(For each material defined in the file, repeat this sequence of
commands, beginning by defining variables for each material property
of concern.)
WHILE vunino GE vunict THEN
   SET VAR vea     REAL
   SET VAR veb     REAL
   SET VAR vec     REAL
   SET VAR vprba   REAL; *(Stress in a; strain in b--major NU)
   SET VAR vprab   REAL; *(Stress in b; strain in a--minor NU)
   SET VAR vprcb   REAL
   SET VAR vprca   REAL
   SET VAR vro     REAL
   SET VAR vgab    REAL
   SET VAR vhgq    REAL
   SET VAR vtranse REAL
   SET VAR x       REAL
   SET VAR y       REAL
   SET VAR xx      REAL
   SET VAR yy      REAL
   SET VAR xy      REAL
   SET VAR zz      REAL
   SET VAR vrepl   TEXT
   SET VAR vtype   TEXT
   SET VAR vorient REAL
   SET VAR det     REAL

*(Run UNINAME.CMD to prompt user for the material to be defined.
Allow the user to list all available composites by typing [ENTER].  If
the user has elected to define fewer unidirectional materials than the
current material count, exit the subroutine.)
   RUN uniname.cmd
```

```
   IF vunino LT vunict THEN
      GOTO endrout
   ENDIF

*(Determine whether user is defining an axisymmetric or 2-dimensional
plane solid.)
   CLS FROM 9
   WRITE "TYPE [P] IF DEFINING A 2-DIMENSIONAL PLANE SOLID IN THE " AT
10 10
   WRITE "X-Y PLANE; TYPE [A] IF DEFINING AN AXISYMMETRIC SOLID WITH "
AT 11 10
   WRITE "SYMMETRY AROUND THE Y-AXIS IN THE Z-DIRECTION.  " AT 12 10
   FILLIN vtype=0 USING " " AT 13 10
   WHILE vtype NE P AND vtype NE A THEN
      CLS FROM 14
      WRITE "INCORRECT SELECTION.  TRY AGAIN..." AT 14 10
      FIL vtype=0 USI "TYPE [P] FOR PLANE; [A] FOR AXISYMMETRIC. " AT
15 10
   ENDWHILE

*(Define a MAZE axisymmetric solid.  First, determine whether the
solid is hoop-wound or radial.)
   IF vtype EQ A THEN
      SET VAR vtype TO -0-
      FILLIN vtype=0 USING +
        "TYPE [H] IF THE COMPOSITE IS HOOP-WOUND; TYPE [R] IF RADIAL.
" AT 14 10
      WHILE vtype NE H AND vtype NE R THEN
         WRITE "INCORRECT ANSWER.  TRY AGAIN..." AT 16 10
         FILLIN vtype=0 USING +
            "TYPE [H] FOR HOOP-WOUND; TYPE [R] FOR RADIAL. " AT 17 10
         CLS FROM 16
      ENDWHILE

*(Find angle of orientation of the composite fiber.)
      CLS FROM 16
      IF vtype EQ H THEN
         WRI "ENTER THE ANGLE BY WHICH THE COMPOSITE FIBER DIRECTION
IS " +
             AT 16 10
         WRI "ROTATED FROM THE MAZE GLOBAL HOOP DIRECTION (Z-AXIS). "
AT 17 10
         FIL vorient USI "CONSIDER COUNTER-CLOCKWISE TO BE POSITIVE:
" AT 18 10
      ENDIF
      IF vtype EQ R THEN
         WRI "ENTER THE ANGLE BY WHICH THE COMPOSITE FIBER DIRECTION
IS " +
            AT 16 10
         FILLIN vorient USING +
            "FROM THE MAZE GLOBAL X-AXIS (COUNTER-CLOCKWISE POSITIVE):
" +
            AT 17 10
      ENDIF
```

```
   ENDIF

*(Define a MAZE 2-dimensional plane solid.  Prompt the user to specify
the angle of rotation between the composite fibers and the MAZE global
x-axis.)
   IF vtype EQ P THEN
      WRI "ENTER THE ANGLE BY WHICH THE COMPOSITE FIBER DIRECTION IS
ROTATED" +
         AT 14 10
      FILLIN vorient USING +
         "FROM THE MAZE GLOBAL X-AXIS (COUNTER-CLOCKWISE POSITIVE):  "
AT 15 10
   ENDIF

   CLS FROM 9
   WRITE "CREATING MAZE DATA BLOCK..." AT 10 10

*(Obtain material property EA from the database.  If the field is
null, allow the user to either enter an approximate value or abort
further processing.)
   SET VAR vea TO ex IN #2
   IF vea FAILS THEN
      SET VAR vrepl TO "EA"
      RUN fix.cmd
      IF vfix NE E THEN
         SET VAR vlamno TO 0
         GOTO endrout
      ENDIF
   ENDIF

*(Repeat above procedure to obtain material property EB.  Direction C
is also transverse to the fiber, therefore EC equals EB.)
   SET VAR veb TO ey IN #2
   IF veb FAILS THEN
      SET VAR vrepl TO "EB"
      RUN fix.cmd
      IF vfix NE E THEN
         SET VAR vlamno TO 0
         GOTO endrout
      ENDIF
   ENDIF

*(Repeat above procedure to obtain material property GAB.)
   SET VAR vgab TO gxy IN #2
   IF vgab FAILS THEN
      SET VAR vrepl TO "GAB"
      RUN fix.cmd
      IF vfix NE E THEN
         SET VAR vlamno TO 0
         GOTO endrout
      ENDIF
   ENDIF

*(Repeat above procedure to obtain material property PRBA.)
```

```
   SET VAR vprba TO nuyx IN #2
   IF vprba FAILS THEN
      SET VAR vrepl TO "PRBA"
      RUN fix.cmd
      IF vfix NE E THEN
         SET VAR vlamno TO 0
         GOTO endrout
      ENDIF
   ENDIF

*(Obtain DENSITY from the database or from the user.)
   SET VAR vro TO dens IN #2
   IF vro FAILS THEN
      SET VAR vrepl TO "RO"
      RUN fix.cmd
      IF vfix NE E THEN
         SET VAR vlamno TO 0
         GOTO endrout
      ENDIF
   ENDIF

*(Hold transverse direction properties to be used for weak-axis after
rotation.)
   SET VAR vtranse TO .veb

*(If rotation of the composite's coordinate system is necessary,
generate on-axis stiffness matrix and transform the values by running
T4.CMD, which performs a fourth rank tensor transform.  Solve for the
transformed material properties.)
   SET VAR vprab TO (.vprba * .veb / .vea)
   IF vorient NE 0 THEN
      SET VAR zz TO .vgab
      SET VAR xx TO (.vea / (1 - .vprba * .vprab))
      SET VAR yy TO (.veb / (1 - .vprba * .vprab))
      SET VAR xy TO (.vprba * .yy)
      RUN t4.cmd
      SET VAR det   TO ((.txx*.tyy - .txy*.txy)*.tzz +
(2*.txy*.tyz*.txz))
      SET VAR det   TO (.det - (.txx*.tyz*.tyz) - (.tyy*.txz*.txz))
      SET VAR vea   TO (.det / (.tyy*.tzz - .tyz*.tyz))
      SET VAR veb   TO (.det / (.txx*.tzz - .txz*.txz))
      SET VAR vgab  TO (.det / (.txx*.tyy - .txy*.txy))
      SET VAR vprba TO (0 - (.txz*.tyz - .txy*.tzz)/(.tyy*.tzz -
.tyz*.tyz))
      SET VAR vprab TO (.vprba * .veb / .vea)
      CLEAR txx tyy txy txz tyz tzz
   ENDIF

*(If hoop-wound, change the a-b axis properties to b-c axis
properties.  Otherwise, let c-axis take transverse direction
properties.)
   IF vtype EQ H THEN
      SET VAR vec TO .vea
      SET VAR vgab TEXT
```

```
      SET VAR vgab TO ***
      SET VAR vprcb TO .vprab
      SET VAR vprba TEXT
      SET VAR vprba TO ***
      SET VAR vprca TEXT
      SET VAR vprca TO ***
      SET VAR vea TO .vtranse
   ELSE
      SET VAR vec TO .vtranse
      SET VAR vprcb TEXT
      SET VAR vprcb TO ***
      SET VAR vprca TEXT
      SET VAR vprca TO ***
   ENDIF

*(Run MAZFGEN.CMD to generate a temmporary file containing a data
block of material properties for the material being defined.)
   RUN mazfgen.cmd

*(Prepare for next iteration by clearing variables and incrementing
counts.)
   CLS FROM 9
   SET VAR vmatct TO (.vmatct + 1)
   SET VAR vunict TO (.vunict + 1)
   CLEAR vea veb vec vprab vprba vprcb vprca vro vgab vh q x y xx yy
det vrepl
   CLEAR vtype vorient vfix vmat vgbc vgac zz xy vtranse
ENDWHILE
LABEL endrout
```

MAZLAM.CMD

```
*(MAZLAM.CMD:  Gathers data specific to each laminated composite mat-
erial being defined in MAZE and prints it to a temporary data file.)

*(For each material defined in the file, repeat this sequence of
commands, beginning by defining variables for each material property
of concern.)
WHILE vlamno GE vlamct THEN
   SET VAR vea     REAL
   SET VAR veb     REAL
   SET VAR vec     REAL
   SET VAR vprba   REAL
   SET VAR vprcb   REAL
   SET VAR vprca   REAL
   SET VAR vro     REAL
   SET VAR vgab    REAL
   SET VAR vhgq    REAL
   SET VAR vtranse REAL
   SET VAR vfix    TEXT
   SET VAR vrepl   TEXT
   SET VAR vtype   TEXT
   SET VAR vunid   TEXT
```

```
*(Run LAMNAME.CMD to prompt user for the material to be defined in the
data file.  Allow the user to place a new laminate definition into the
database if necessary, or list all available composites by typing
[ENTER].  If the user has elected to define fewer laminated materials
in the data file than the current material count, exit the
subroutine.)
   RUN lamname.cmd
   IF vlamno LT vlamct THEN
      GOTO endrout
   ENDIF

*(Determine whether user is defining an axisymmetric solid or a two
dimensional plane solid.)
   CLS FROM 9
   WRITE "TYPE [P] IF DEFINING A 2-DIMENSIONAL PLANE SOLID IN THE " AT
10 10
   WRITE "X-Y PLANE; TYPE [A] IF DEFINING AN AXISYMMETRIC SOLID WITH"
AT 11 10
   WRITE "SYMMETRY AROUND THE Y-AXIS IN THE Z-DIRECTION.  " AT 12 10
   FILLIN vtype=0 USING " " AT 13 10
   WHILE vtype NE P AND vtype NE A THEN
      CLS FROM 14
      WRITE "INCORRECT SELECTION.  TRY AGAIN..." AT 14 10
      FIL vtype=0 USING "TYPE [P] FOR PLANAR; [A] FOR AXISYMMETRIC."
AT 15 10
   ENDWHILE

*(Define a MAZE axisymmetric solid.  First determmine whether the
solid is hoop-wound or radial.)
   IF vtype EQ A THEN
      SET VAR vtype TO -0-
      FILLIN vtype=0 USING +
        "TYPE [H] IF THE COMPOSITE IS HOOP-WOUND; TYPE [R] IF RADIAL.
" AT 14 10
      WHILE vtype NE H AND vtype NE R THEN
         WRITE "INCORRECT ANSWER.  TRY AGAIN..." AT 16 10
         FILLIN vtype=0 USING +
            "TYPE [H] FOR HOOP-WOUND; TYPE [R] IF RADIAL. " AT 17 10
         CLS FROM 14
      ENDWHILE
   ENDIF

   CLS FROM 9
   WRITE "CREATING MAZE DATA BLOCK..." AT 10 10

*(Obtain material property E1 from the database.  Note that 1 refers
to the major axis and 2 refers to the minor axis.)
   SET VAR vea TO e1 IN #2

*(Also obtain material properties E2, NU21, and G12 from the
database.)
   SET VAR veb TO e2 IN #2
   SET VAR vprba TO nu21 IN #2
```

```
   SET VAR vprab TO (.vprba * .veb / .vea)
   SET VAR vgab TO g12 IN #2

*(Obtain DENSITY and E(trans) from unidirectional composite data in
the database; if either is not available; prompt the user.)
   SET VAR vunid TO unid IN laminate WHERE lamid EQ .vmat
   SET VAR vro TO dens IN uniprop WHERE unid EQ .vunid
   IF vro FAILS THEN
      SET VAR vrepl TO "RO"
      RUN fix.cmd
      IF vfix NE E THEN
         GOTO endrout
      ENDIF
   ENDIF
   SET VAR vec TO ey IN uniprop WHERE unid EQ .vunid
   IF vec FAILS THEN
      SET VAR vrepl TO "Ethick"
      RUN fix.cmd
      IF vfix NE E THEN
         GOTO endrout
      ELSE
         SET VAR vec TO .vethick
      ENDIF
   ENDIF

*(If composite is hoop-wound, change a-b plane properties to b-c
plane; let a-axis take transverse properties.  Otherwise, let c-axis
take transverse properties.)
   IF vtype EQ H THEN
      SET VAR vtranse TO .vec
      SET VAR vec TO .vea
      SET VAR vgab TEXT
      SET VAR vgab TO ***
      SET VAR vprba TEXT
      SET VAR vprba TO ***
      SET VAR vprca TEXT
      SET VAR vprca TO ***
      SET VAR vprcb TO .vprab
      SET VAR vea TO .vtranse
   ELSE
      SET VAR vprcb TEXT
      SET VAR vprcb TO ***
      SET VAR vprca TEXT
      SET VAR vprca TO ***
   ENDIF

*(Run MAZFGEN.CMD to generate a temmporary file containing a data
block of material properties for the material being defined.)
   RUN mazfgen.cmd

*(Prepare for next iteration by clearing variables and incrementing
counts.)
   CLS FROM 9
   SET VAR vmatct TO (.vmatct + 1)
```

```
   SET VAR vlamct TO (.vlamct + 1)
   CLEAR vea veb vec vprba vprcb vprca vro vgab vrepl vtype vmat vfix
   CLEAR vunid
ENDWHILE
LABEL endrout
```

MAZFGEN.CMD

```
*(MAZFGEN.CMD:  Run from MAZLAM.CMD and MAZUNI.CMD, generates actual
temporary file containing material properties for a single unidirec-
tional or laminated composite material.)

*(Define appropriate variables.)
SET VAR vcom   TEXT
SET VAR vdot   INTEGER
SET VAR vkeep  INTEGER
SET VAR vdata  TEXT
SET VAR vhead  TEXT
SET VAR vtitle TEXT
SET VAR vhgq   REAL


*(Obtain all of the material properties for the material currently
being defined and print it to a temporary file along with a header.
Begin by prompting user for a header.)
CLS FROM 11
WRITE "ENTER A HEADING FOR THIS MATERIAL DEFINITION OF EIGHTY OR
FEWER" AT 12 10
WRITE "CHARACTERS, OR TYPE [ENTER] TO ACCEPT DEFAULT HEADING. " AT 13
10
FILLIN vhead USING ">" AT 14 10
IF vhead FAILS THEN
   SET VAR vhead TO ("ORTHO. ELAS. MAT.:" & (LUC(.vmat)) + ",
COMPOSITE")
ENDIF

*(Prompt user for hourglass coefficient, check that it is within
limits, and truncate it to six characters past the decimal place.)
CLS FROM 11
FILLIN vhgq USING "ENTER HOURGLASS ""Q"" (0.0 < Q < 0.1):  " AT 12 10
WHILE vhgq LT 0.0 OR vhgq GT 0.1 THEN
   CLS FROM 12
   WRITE "NOT WITHIN THE STATED LIMITS.  TRY AGAIN. " AT 14 10
   FILLIN vhgq USING "ENTER HOURGLASS ""Q"" (0.0 < Q < 0.1):  " AT 15
10
ENDWHILE
SET VAR vhgq TEXT
SET VAR vhgq TO (LJS(.vhgq,8))
CLS FROM 11

*(Open a temporary file for the material definition.  Generate and
print header for the material into the file.)
SET VAR vmatct TEXT
```

```
SET VAR vtmpfile TO ("MAT" + .vmatct)
OUTPUT .vtmpfile
SET VAR vtitle TO ("MAT" & .vmatct & "2 HEAD")
SET VAR vmatct INTEGER
WRITE .vtitle
WRITE .vhead

*(For each material, print to the file a line of text containing a
label and the corresponding material property.  Truncate the material
property to six characters past the decimal place and print it to the
file along with the appropriate label.  This sequence is first used
for property EA.)
SET VAR vea TEXT
SET VAR vdot TO (SLOC(.vea,"."))
SET VAR vkeep TO (.vdot + 6)
SET VAR vea TO (SGET(.vea,.vkeep,1))
SET VAR vdata TO ("EA" & .vea)
WRITE .vdata

*(Print the label and value for EB.)
SET VAR veb TEXT
SET VAR vdot TO (SLOC(.veb,"."))
SET VAR vkeep TO (.vdot + 6)
SET VAR veb TO (SGET(.veb,.vkeep,1))
SET VAR vdata TO ("EB" & .veb)
WRITE .vdata

*(Print the label and value for EC.)
SET VAR vec TEXT
SET VAR vdot TO (SLOC(.vec,"."))
SET VAR vkeep TO (.vdot + 6)
SET VAR vec TO (SGET(.vec,.vkeep,1))
SET VAR vdata TO ("EC" & .vec)
WRITE .vdata

*(Print the value and label for PR (poisson's ratio) BA.)
SET VAR vprba TEXT
SET VAR vdot TO (SLOC(.vprba,"."))
SET VAR vkeep TO (.vdot + 6)
SET VAR vprba TO (SGET(.vprba,.vkeep,1))
SET VAR vdata TO ("PRBA" & .vprba)
WRITE .vdata

*(Print the value and label for PR CB.)
SET VAR vprcb TEXT
SET VAR vdot TO (SLOC(.vprcb,"."))
SET VAR vkeep TO (.vdot + 6)
SET VAR vprcb TO (SGET(.vprcb,.vkeep,1))
SET VAR vdata TO ("PRCB" & .vprcb)
WRITE .vdata

*(Print the value and label for PR CA.)
SET VAR vprca TEXT
SET VAR vdot TO (SLOC(.vprca,"."))
```

```
SET VAR vkeep TO (.vdot + 6)
SET VAR vprca TO (SGET(.vprca,.vkeep,1))
SET VAR vdata TO ("PRCA" & .vprca)
WRITE .vdata

*(Print the label and value for RO (density).)
SET VAR vro TEXT
SET VAR vdot TO (SLOC(.vro,"."))
SET VAR vkeep TO (.vdot + 6)
SET VAR vro TO (SGET(.vro,.vkeep,1))
SET VAR vdata TO ("RO" & .vro)
WRITE .vdata

*(Print the label and value for G AB.)
SET VAR vgab TEXT
SET VAR vdot TO (SLOC(.vgab,"."))
SET VAR vkeep TO (.vdot + 6)
SET VAR vgab TO (SGET(.vgab,.vkeep,1))
SET VAR vdata TO ("GAB" & .vgab)
WRITE .vdata

*(Print the remaining nonvariable MAZE commands to the file.)
WRITE "AOPT 2.0"
WRITE "RP "
WRITE "ZP "
WRITE "PSIG 0.0"
SET VAR vhgq TO ("HGQ" & .vhgq)
WRITE .vhgq
WRITE "ENDMAT"
WRITE " "

*(Prepare for the next iteration by incrementing the material count
and clearing the variables representing material properties.)
OUTPUT SCREEN
CLS FROM 9
WRITE "DATA BLOCK COMPLETE.  PRESS ANY KEY TO CONTINUE. " AT 10 10
PAUSE
CLS FROM 9
CLEAR vcom vdot vkeep vdata vhgq vhead vtitle
```

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APPENDIX 6:

DATABASE SCHEMA

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Appendix 6: Database Schema

Following is the actual database schema of the Composites Database used to demonstrate the overall capabilities of the CDI system. Each table is documented along with its associated columns. A separate list of columns, indicating data types and lengths, is also included. The data is displayed by issuing the following R:BASE commands:

```
R>OPEN COMP
R>LIST TABLES
R>LIST TABLES ALL
R>LIST COLUMNS
```

The OPEN command loads the database COMP into the computer's main memory, making it accessible to the DBMS. The LIST TABLES command enumerates the tables in the database and lists the number of rows in each. The LIST TABLES ALL command lists the columns contained within each table, identifying their data types and the key columns. It also states the number of rows in each table. Finally, the LIST COLUMNS command enumerates all columns in the COMP database in alphabetical order, again with the data type and keys identified. The applicable command is noted in parentheses prior to its output.

```
(OPEN COMP)
 Database exists

(LIST TABLES)

   Tables in the Database COMP

   Name      Columns    Rows                     Name      Columns    Rows

   REPORTS         2     123                     FORMS           2     171
   LAMINATE        3       3                     UNICOMP         7       2
   LAMPROP        14       3                     UNIPROP         9       2

(LIST TABLES ALL)

   Table: REPORTS            No lock(s)
   Read Password: No
   Modify Password: No

   Column definitions
   # Name     Type      Length         Key    Expression
   1 RNAME    TEXT        8 characters yes
   2 RDATA    TEXT       80 characters

   Current number of rows:     123

   Table: FORMS              No lock(s)
   Read Password: No
   Modify Password: No

   Column definitions
   # Name     Type      Length         Key    Expression
   1 FNAME    TEXT        8 characters yes
```

2 FDATA	TEXT	46 characters

Current number of rows: 171

Table: LAMINATE No lock(s)
Read Password: No
Modify Password: No

Column definitions

#	Name	Type	Length	Key	Expression
1	LAMID	TEXT	8 characters	yes	
2	UNID	TEXT	8 characters		
3	LAMCODE	TEXT	20 characters		

Current number of rows: 3

Table: UNICOMP No lock(s)
Read Password: No
Modify Password: No

Column definitions

#	Name	Type	Length	Key	Expression
1	UNID	TEXT	8 characters	yes	
2	UNINAME	TEXT	12 characters		
3	CLASS	TEXT	12 characters		
4	FIBER	TEXT	8 characters		
5	MATRIX	TEXT	8 characters		
6	PRODFORM	TEXT	20 characters		
7	PROCESS	TEXT	20 characters		

Current number of rows: 2

Table: LAMPROP No lock(s)
Read Password: No
Modify Password: No

Column definitions

#	Name	Type	Length	Key	Expression
1	LAMID	TEXT	8 characters	yes	
2	A11	REAL			
3	A12	REAL			
4	A16	REAL			
5	A22	REAL			
6	A26	REAL			
7	A66	REAL			
8	E1	REAL			
9	E2	REAL			
10	G12	REAL			
11	NU21	REAL			
12	ALP1	REAL			
13	ALP2	REAL			
14	ALP12	REAL			

Current number of rows: 3

Table: UNIPROP   No lock(s)
Read Password: No
Modify Password: No

Column definitions

#	Name	Type	Length	Key	Expression
1	UNID	TEXT	8 characters	yes	
2	EX	REAL			
3	EY	REAL			
4	ALPX	REAL			
5	ALPY	REAL			
6	NUYX	REAL			
7	NUXY	REAL			'NUYX'*'EY'/'EX'
8	DENS	REAL			
9	GXY	REAL			

Current number of rows: 2

(LIST COLUMNS)

Column definitions

Name	Type	Length	Table	Key	Expression
A11	REAL		LAMPROP		
A12	REAL		LAMPROP		
A16	REAL		LAMPROP		
A22	REAL		LAMPROP		
A26	REAL		LAMPROP		
A66	REAL		LAMPROP		
ALP1	REAL		LAMPROP		
ALP12	REAL		LAMPROP		
ALP2	REAL		LAMPROP		
ALPX	REAL		UNIPROP		
ALPY	REAL		UNIPROP		
CLASS	TEXT	12 characters	UNICOMP		
DENS	REAL		UNIPROP		
E1	REAL		LAMPROP		
E2	REAL		LAMPROP		
EX	REAL		UNIPROP		
EY	REAL		UNIPROP		
FDATA	TEXT	46 characters	FORMS		

Column definitions

Name	Type	Length	Table	Key	Expression
FIBER	TEXT	8 characters	UNICOMP		
FNAME	TEXT	8 characters	FORMS	yes	
G12	REAL		LAMPROP		
GXY	REAL		UNIPROP		
LAMCODE	TEXT	20 characters	LAMINATE		
LAMID	TEXT	8 characters	LAMINATE	yes	
			LAMPROP	yes	
MATRIX	TEXT	8 characters	UNICOMP		
NU21	REAL		LAMPROP		
NUXY	REAL		UNIPROP		

'NUYX'*'EY'/'EX'

NUYX	REAL		UNIPROP	
PROCESS	TEXT	20 characters	UNICOMP	
PRODFORM	TEXT	20 characters	UNICOMP	
RDATA	TEXT	80 characters	REPORTS	
RNAME	TEXT	8 characters	REPORTS	yes
UNID	TEXT	8 characters	UNIPROP	yes
			LAMINATE	
			UNICOMP	yes

Column definitions

Name	Type	Length	Table	Key	Expression
UNINAME	TEXT	12 characters	UNICOMP		

APPENDIX 7:

LAMINATED PLATE THEORY

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Appendix 7: Laminated Plate Theory

Included in this index are the laminated plate theory equations applicable to the design of both quasi-isotropic and general laminates. The information presented here is a brief synopsis of chapters four through seven of Composites Design by Steven Tsai [3]. Where appropriate, the corresponding section numbers from the book are referenced. In some instances, the variable naming convention has been slightly altered.

For the unidirectional composite in question, the following material properties must be known: elastic modulus in fiber direction (Ex), elastic modulus in transverse direction (Ey), major Poisson's ratio (NUyx), and shear modulus of elasticity (G).

First, the coefficients of the on-axis stiffness matrix, Q, for the unidirectional ply must be computed using the following equations (Sec 4.3):

```
NUxy = NUyx * Ey / Ex
Qxx = Ex / (1 - (NUxy * NUyx))
Qyy = Ey / (1 - (NUxy * NUyx))
Qxy = NUyx * Qyy = NUxy * Qxx
Qss = G
```

The stiffness coefficients for the ply correspond to the Q matrix as follows (Sec 6.1):

```
        |   Qxx   Qxy   0     |
[Q] =   |   Qxy   Qyy   0     |
        |   0     0     Qss   |
```

To determine normalized stiffness coefficients for a quasi-isotropic laminate, with equal plys at each forty-five degree angle, the invariants of coordinate transformation are used (Sec 6.2, Sec 6.3). The applicable equations are:

```
U1 = (3/8)*Qxx + (3/8)*Qyy + (1/4)*Qxy + (1/2)*Qss
U4 = (1/8)*Qxx + (1/8)*Qyy + (3/4)*Qxy - (1/2)*Qss
U5 = (1/8)*Qxx + (1/8)*Qyy - (1/4)*Qxy + (1/2)*Qss
```

The invariants correspond to the normalized quasi-isotropic stiffness matrix as follows:

```
             |   U1   U4   0    |
[Q]iso =     |   U4   U1   0    |
             |   0    0    U5   |
```

Finally, material properties for the quasi-isotropic laminate can be determined with these equations:

```
Eiso = (U1**2 - U4**2) / U1
NUiso = U4 / U1
Giso = U5
```

For a general laminate, i.e. not quasi-isotropic, the on-axis stiffness coefficients for each ply in the laminate must first be transformed by the angle of rotation from the major axis. Counter-clockwise transformations are considered positive (Sec 6.1). The transformation equations, from Table 6.2, are:

```
Q11 = m**4 * Qxx + n**4 * Qyy + 2*m*m*n*n * Qxy + 4*m*m*n*n * Qss
Q22 = n**4 * Qxx + m**4 * Qyy + 2*m*m*n*n * Qxy + 4*m*m*n*n * Qss
Q12 = m*m*n*n * Qxx + m*m*n*n * Qyy + (m**4 + m**4) * Qxy - 4*m*m*n*n * Qss
Q66 = m*m*n*n * Qxx + m*m*n*n * Qyy - 2*m*m*n*n * Qxy + (m*m - n*n)**2
```

```
Q16 = m**3*n * Qxx - m*n**3 * Qyy + (m*n**3 - m**3*n) * Qxy + 2*(m*n**3-m**3*n) * Qss
Q26 = m*n**3 * Qxx - m**3*n * Qyy + (m**3*n - m*n**3) * Qxy + 2*(m**3*n-m*n**3)
```

where m is the cosine of the angle of rotation and n is the sine of the angle. The transformed stiffness coefficients correspond to the ply transformed stiffness matrix as follows:

$$[Q'] = \begin{vmatrix} Q11 & Q12 & Q16 \\ Q12 & Q22 & Q26 \\ Q16 & Q26 & Q66 \end{vmatrix}$$

To find the total normalized stiffness matrix, A*, for the general laminate, we must take a weighted average of each ply by multiplying the stiffness coefficients for that layer by the corresponding volume fraction. This is known as the rule-of-mixtures method (Sec 7.6), and is described by the following equation:

```
[A*] = SUM { [Q'](i) * vol(i) }
```

In other words, the transformed stiffness matrix coefficient (Q') for each ply is multiplied by the volume fraction (vol) of that layer; the result is summed for all layers by each coefficient. For example, the terms in the first row and second column of the matrix can be summed for each layer as follows:

```
A12 = SUM { Q12(i) * vol(i) }
```

The total normalized stiffness matrix for the laminate can, therefore, be written as:

$$[A*] = \begin{vmatrix} A11 & A12 & A16 \\ A12 & A22 & A26 \\ A16 & A26 & A66 \end{vmatrix}$$

Laminate material properties are calculated by inverting several stiffness coefficients, as described below (Sec 7.3, Sec 7.4):

```
DET(A) = (A11*A22-A12**2)*A66 + 2*A12*A26*A16 -
A11*A26**2 - A22*A16**2
E1 = DET(A) / (A22*A66 - A26**2)
E2 = DET(A) / (A11*A66 - A16**2)
E6 = DET(A) / (A11*A22 - A11*A26)
NU21 = -(A16*A26 - A12*A66) / (A22*A66 - A26**2)
```

where E1 and E2 are the elastic moduli at zero and ninety degrees of rotation, respectively, E6 is the shear modulus of elasticity, and NU21 is the major Poisson's ratio for the entire general laminate.

Like stiffness coefficients, thermal expansion coefficients are transformed by the angle of rotation of each composite layer, and summed over the laminate cross-section (Sec 5.1). For a single ply, the transformation equations are as follows:

```
ALPX(T) = m*m*ALPX + n*n*ALPY + 2*m*n*ALPXY
ALPY(T) = n*n*ALPX + m*m*ALPY - 2*m*n*ALPXY
ALPXY(T) = -(m*n)*ALPX + m*n*ALPY + (m*m-n*n)*ALPXY
```

where m is the cosine of the angle of rotation and n is the sine. The thermal expansion coefficients for the entire laminate are calculated by summing the coefficients for each ply multiplied by the volume fraction of that layer.

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